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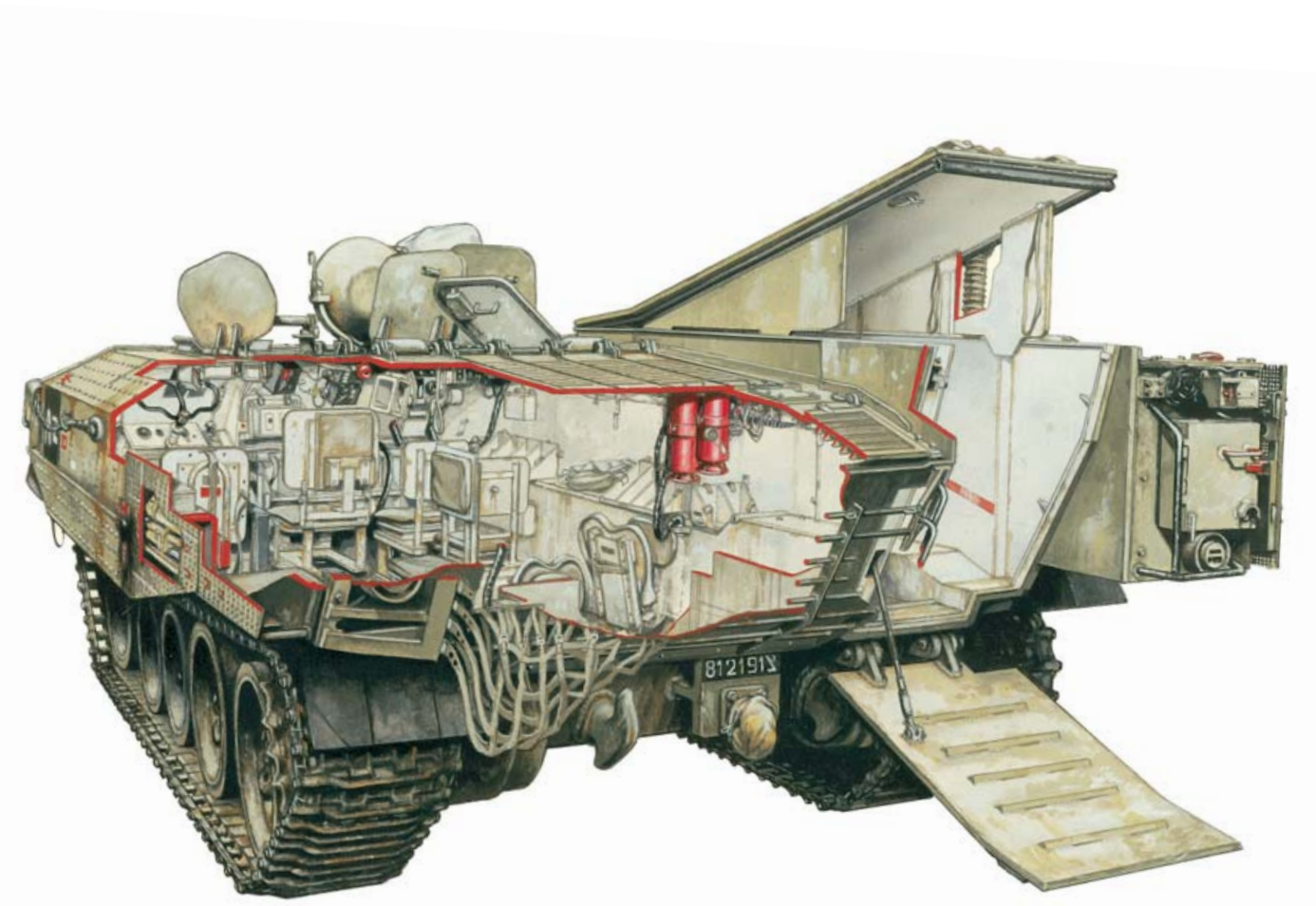
Modern Israeli Tanks and Infantry Carriers 1985–2004



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New Vanguard • 93

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MODERN ISRAELI TANKS AND INFANTRY CARRIERS 1985–2004

THE BACKGROUND SITUATION

The 1973 Yom Kippur War taught the Israel Defence Force (IDF) that its tanks and infantry carriers were vulnerable to man-portable anti-tank weapons. By the end of the war the wastelands of Sinai and the basalt-strewn fields of the Golan Heights were littered with the carcasses of damaged or destroyed Israeli armoured vehicles.

The infantry weapons that wreaked such havoc carried high explosive anti-tank (HEAT) warheads. These warheads use shaped charges, consisting of a copper-lined cone pre-formed inside an explosive cylinder. When it hits a target, the HEAT round explodes, instantly squeezing the copper lining into a thin, high energy linear jet. The jet moves forward as fast as 8km/second, cutting through steel, destroying a target and killing its crew.

The IDF learned from the Yom Kippur conflict. By the 1982 Lebanon war, it had equipped its tanks with bolt-on blocks of Blazer explosive reactive armour (ERA), specifically designed to defeat HEAT charges. Blazer utilises a thin layer of insensitive explosive material sandwiched at an oblique angle, within two steel plates. When initiated by the impact of a HEAT round, the explosive within a Blazer block detonates, blasting the metal plates of the ERA sandwich into the path of the round's cutting jet as it begins to form. This disrupts the coherence of the jet, greatly reducing its destructive power before it reaches the tank's main armour. In the 1982 war, Blazer was able to defeat the HEAT warheads

This Magach 6B is fitted with late 1980s vintage Super Blazer explosive reactive armour tiles. Second generation Blazer had an improved performance when compared with that used in the 1982 Lebanon war, but remained relatively ineffective against KE rounds. (IMI)

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An IDF M113 APC, photographed in 2000. This example has been fitted with shields to protect the heads and upper torsos of the vehicle's commander and passengers against small arms fire. The APC remains vulnerable to RPGs and other light anti-tank weapons.

then used in anti-tank missiles and some tank shells. Consequently Israeli tanks were well protected against infantry anti-tank weapons such as the rocket-propelled grenade (RPG). However, Blazer was only a partial solution. It could not defeat the kinetic energy (KE) rounds fired by tank cannon. These use dart-shaped penetrators made up of heavy metals such as tungsten or depleted uranium. The penetrators move at enormous velocity and can carve through tank armour even when supplemented with Blazer.

In the 1982 conflict Israeli armoured personnel carriers (APCs), then mainly the M113 type, remained hopelessly at risk from light anti-tank weapons. First generation Blazer had two characteristics which made it unsuitable for infantry carriers. Firstly, it was too heavy. Secondly, when Blazer modules were detonated, there was considerable back-blast. The thin armored shell of a typical APC couldn't withstand this without damage.

Other than the overwhelming need to develop a survivable infantry carrier, several distinct but interrelated problems troubled the IDF's Armoured Corps.

- The lack of a robust combat engineer vehicle. The IDF's difficulties in the 1982 war were compounded by the lack of a survivable combat engineer vehicle, capable of clearing away field fortifications and minefields. Stalled armoured columns cost lives.
- The need to introduce a heavily armoured vehicle suitable for low intensity conflict (LIC). From the late 1980s onwards, the IDF faced determined guerrilla attacks from Hezbollah and other organisations. Once again infantry carriers such as the M113 proved particularly vulnerable.
- The Israelis were increasingly aware that their tank fleet was verging on obsolescence and that, in particular, levels of protection were inadequate. With the exception of the indigenous Merkava, most Israeli tanks dated back to the 1960s. As the Israelis could not build enough Merkavas to replace all their obsolescent tanks, ways had to be found to improve the survivability of the older machines.

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Short term solution – updating the M113

Around 5,900 M113s are in IDF service. For the foreseeable future, they will remain the IDF's baseline infantry carrier. Although available, reliable and relatively cheap, the M113 is vulnerable to weapons such as the ubiquitous RPG. The RPG is found amongst regular armies and insurgent forces all over the Middle East and is an easily portable, cheap killing tool. Typically an RPG can cut through 350mm of rolled homogeneous armour (RHA).

Modern light anti-tank weapons like the RPG are also becoming increasingly sophisticated. They now often carry tandem warheads capable of defeating ERA. When the first explosive charge detonates, it blasts away ERA bricks; the second pierces the tank's main armour. A typical new generation warhead is fitted to the RPG 7VR; it can strip explosive reactive armour from a tank's hull and then pierce 600mm RHA. Even the earlier RPGs hopelessly overmatch the protective aluminium armour of Israel's M113 infantry carriers, which is only 44mm at its thickest.

Faced with such formidable opposition, the M113 rapidly gained the reputation in Israeli service, of being a mobile field crematorium.

In the wake of the 1982 Lebanon war and the casualties inflicted on its mechanised infantry by RPGs, the IDF re-evaluated the expected role and actual performance of its infantry carriers. The Israelis concluded that an APC, by virtue of its function, is exposed to greater risk than a tank. A tank can dominate an objective by fire at a distance, whilst an infantry carrier must traverse a fire zone in order to deliver its infantry onto that same objective. Given their extreme sensitivity to casualties, the Israelis wanted a heavy APC – an assault carrier – that could traverse the fire zone, with a chance of survival at least as good as that of an MBT. No such vehicle was available. It would require designing from scratch.

In the interim, desperate efforts were made to improve the survivability of the M113. Perforated steel mesh armour screens, known as Toga, were fitted to the flanks and front of some Israeli M113s. These screens, fitted some 250mm away from the baseline aluminium shell of the M113, act as

Toga perforated steel mesh plates have been fitted to this Israeli M113. This type of stand-off armour offers improved protection against machine-gun fire and RPGs. The photo was taken in the mid-1990s by Sean Curtis, from the UNIFIL position within Lebanon known as the 'Black Hole'.

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ABOVE **The ultimate M113 armour upgrade, the Classical, *circa* 1997. Lightweight explosive reactive armour tiles offer protection against HEAT warheads. The roof-mounted 'birdcage' protects exposed crewmen against small arms fire. (Rafael)**

OPPOSITE **A Nagmashot carrier manned by Israeli combat engineers. The photo is dated to the mid-1980s. The machine retains the original Centurion side skirts. Note the clumsy minefield shoes mounted on the flanks of the crew compartment. (IDF)**

a type of stand-off armour. Toga offers some protection against small arms' fire and pieces of shrapnel. These fragment when they impact on the mesh. The 250mm distance between the mesh screen and the main armour allows the fragments space to tumble and yaw. This diminishes their penetrating power, before they hit the M113's hull. Without Toga an M113's baseline armour can stop 7.62mm rifle calibre rounds. For a cost in weight of around 800 kg, an M113 with Toga can defeat 14.5mm armour-piercing, heavy machine-gun rounds.

Toga also acts as a partial defence against RPG-type anti-tank weapons by making their warheads explode prematurely. If the weapon's HEAT jet does manage to penetrate a Toga-equipped M113, then its cone-shaped killing zone is narrowed from approximately 110 degrees to 30 degrees around the axis of entry. This does increase survivability, but is scant comfort to those crewmen or passengers who may have been sitting in the wrong seats at the wrong time.

Israel's most comprehensive armour upgrade of the M113 series involved the fitting of lightweight explosive reactive armour. The new explosive reactive armour used on the M113 is a hybrid using two separate sandwiches. The first sandwich is made up of a layer of thin explosive within steel plates. The second sandwich is made up of an inert elastomer filling held between a second set of steel plates. In combination, the new arrays can defeat RPG warheads and similar threats. However, because of expense, the resultant machine, known as the Classical, has only been built in limited numbers.

Alternatives to the M113

As a possible alternative to the M113, the Israeli armament company Rafael modified a Bradley infantry fighting vehicle (IFV). They removed the Bradley's complex and bulky turret, replacing it with a relatively simple overhead weapon system (OWS). Rafael then added extensive appliqué armour modules. Although removing the turret saved weight, the burden of the appliqué armour modules proved too much for the machine's suspension.

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As there was no vehicle in service anywhere which matched Israeli requirements, they were forced to develop their own design for a heavy infantry carrier. The ideal solution would have been to base the new carrier on the front-engined Merkava MBT. In fact not long after the Merkava 1 entered into service, a platoon of the new tanks were rebuilt as experimental heavy APCs. The Merkava-based carriers were even given an unofficial designation – Nammer. *Nammer* is the Hebrew word for Tiger, but in this case is an acronym made by putting together the two words *Nagmash* (carrier) and *Merkava* (chariot). Expense and the need to prioritise Merkava hulls for use as tanks halted the project.

Subsequently, the Israelis produced a series of stop-gap Centurion-based carriers, for use by infantry and combat engineers. The IDF removed turrets from some of its obsolescent Centurion MBTs, then used the space to build new fighting compartments with a boxy, angular superstructure. Such conversions are often referred to as 'Kangaroo carriers' after their Second World War predecessors. The first IDF Centurion Kangaroo, known as the Nagmashot, appeared in the early 1980s. The Nagmashot lacked a rear exit. As a result, its six-man infantry squad had to disembark over the side of the machine's hull. This had too many tactical disadvantages, and the machine was used mainly by combat engineers rather than infantry formations.

The Achzarit Infantry Assault Carrier

A better solution to finding a heavy, survivable APC was found in IDF storage depots where, since 1967, the Israelis had held many hundreds of captured T-54 and T-55 tanks. They were to form the basis of the Achzarit heavy assault carrier. NIMDA, the manufacturers of the Achzarit, started development work in the early 1980s. The service trials commenced in 1989.

The Achzarit is low slung, with a height of 2 metres. The turret of the parent vehicle, a T-54/55 tank, is first removed and a new fighting compartment is created. This is done by building up the hull sides and providing overhead protection for the crew. The engine is replaced and

Israeli Armour Developments

All the add-on armour that the Israelis have developed offers improved protection and reduced weight when compared with steel rolled homogeneous armour (RHA). The Israelis refer to four generations of armour that they have introduced to supplement RHA. The exact mark of appliqué armour fitted to a vehicle can be discovered by examining a series of small discs attached to the armour modules. The discs are about 5cm in diameter and have embossed upon them a number of vertical lines to indicate the generation of appliqué armour used. Two lines indicates second generation armour, three lines third generation, etc.

The first generation explosive reactive armour, known as Blazer, evolved through at least two types with modified configuration and improved composition.

The second generation armour is made up of layers of different material, probably incorporating ceramics, elastomers and aluminium in combination. This generation of passive armour is characterised by heavy bolts and rivets seen on its surface.

Third generation armour is made up of high-performance passive laminates. It has a relatively smooth surface.

Fourth generation armour may incorporate some integral reactive layers, sandwiched between thicker layers of passive armour. In this type of hybrid, each type of armour enhances the effectiveness of the other.

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re-mounted transversely. When viewed from behind, the new power pack is at the left rear of the vehicle. The transverse mounting allows space for a narrow passenger corridor beside the engine, leading from the fighting compartment to a hydraulically powered clamshell rear exit and ramp. A disadvantage of this design is that when the clamshell door is raised, it indicates to an enemy that troops are about to disembark.

The rear exit of the Achzarit is situated over the transmission. This means that there is a slight upwards incline when you exit the machine. In practice this is not really noticeable and infantry alight from the Achzarit surprisingly rapidly. The long exit ramp has a non-slip, ridged surface which allows the soldiers to maintain a sure footing as they leave the vehicles.

Three crewmen are seated at the front of the machine. When viewed from the rear, from left to right, they comprise the driver, commander and gunner. Whilst the driver and gunner are well served with vision blocks and periscopes, the commander is not. It is clear that, to maintain situational awareness, the commander has to travel with the hatch locked open in a 'raised umbrella' position. This gives decent overhead protection whilst allowing reasonable all-round vision. However, there is a 'dead zone' to the commander's front-right, where the Rafael OWS blocks his view.

Normally seven infantrymen are carried. There is a simple padded bench to the rear left of the compartment. Just to the right/rear of this bench is a single foldable seat. Three more individual folding seats are placed along the right side of the vehicle.

Protection

The Achzarit is the best protected infantry carrier in service and can withstand both HEAT and kinetic energy projectiles which would destroy conventional IFVs. The manufacturers claim that the machine can withstand repeated 125mm KE hits over its frontal arc. At 44 tonnes the machine is exceptionally heavy for an infantry carrier. The fact that 14 tonnes of the vehicle's weight is made up of additional, advanced armour, gives some indication as to its high degree of protection.

Whilst armour has been concentrated on its frontal arc, the Achzarit has been carefully designed so that component parts contribute to its overall survivability. Diesel fuel cells to the rear right and left flanks of the passenger compartment act as spaced armour. The rear sides are covered by Toga armoured mesh plates. These have been cut into sections and hinged. This allows the narrow gap between the mesh and the hull shell to be used as storage space for such items as stretchers and water containers.

Multiple efforts have been made to improve crew survival. A Spectronix fire detection and suppression system using Halon gas is fitted. Crew and passengers are provided with individual NBC protection equipment. Two Israeli Military Industries (IMI) CL-3030 instantaneous self-screening smoke grenade launchers, each with six projectiles, are carried. In addition the Achzarit can inject a fuel aerosol into its engine exhausts in order to produce a smoke screen.

Firepower

The primary target for the Achzarit's armament is enemy infantry. NIMDA originally intended the Achzarit to carry three Rafael OWS. Of a modular

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design, each was capable of being fitted with either a 7.62mm or 12.7mm machine gun. Alternatively an OWS could be adapted to carry a 40mm grenade launcher. However, budgetary constraints saw just one OWS being adopted as standard, fitted with an FN 7.62mm M240 machine gun. The OWS weighs only 160kg and has a minimal internal footprint. The OWS can be fired remotely, with the gunner completely under armour, or manually with the gunner's head and shoulders out of his hatch. When fired under armour, the gunner uses a periscope with a sight of x1 magnification. This allows a 25 degree field of view. A brilliantly illuminated, collimated, red ring comprises the aiming aid. This allows the gunner to traverse and engage a target swiftly and instinctively. An elbow sight, with x8 magnification and ballistic range scale, is fixed to the right of the main sight. Both sights are night capable, with second generation image intensifiers. The Achzarit also carries up to three other FN 7.62mm machine guns on simple pintle mounts and at least one roof-mounted 60mm mortar which can be used to fire illuminating, smoke and anti-personnel rounds.

A female instructor waits by a Rafael OWS. Note the instructor's flak jacket and Type 602 helmet. The optical sight for the OWS is visible below the gun barrel. The knurled wheel to the left of the weapon is a searchlight mount.

Mobility

Perhaps the Achzarit's main failing is that it is relatively under-powered. For purposes of commonality and logistic support, the Achzarit's power pack is based on that used by the M109 self-propelled gun, widely employed by the Israelis. Although NIMDA was more than capable of fitting a more potent engine, funding was unavailable. The initial production model used the Detroit Diesel 8V-71 TTA diesel of 650hp, combined with an Allison XTG-411-4 transmission. This set-up gave the machine a low power-to-weight ratio of 14hp/tonne. Consequently NIMDA introduced the Achzarit 2 with a more powerful 8V-92TA/DDC III engine coupled to the XTG-411-5A transmission. This produces 850hp, giving a power-to-weight ratio of 19.3hp/tonne.

The Achzarit exhibits good cross-country mobility thanks to its modified suspension. This has been upgraded from the T-54/55 original by the Israeli firm Kinetics; it now incorporates modified torsion bars. High-capacity hydraulic bump-stops are now fitted to roadwheels one and five, increasing roadwheel travel from 98mm to 200mm. Perhaps more importantly for the quality of the ride, the new hydraulic bump-stops have increased dissipative energy absorption by a remarkable 750 per cent.

Achzarit in service

It is estimated that 200 to 300 examples of the heavy assault carrier are in service. Achzarit battalions are each made up of some 36 standard machines and one command variant.

The Achzarit was tailored for use as an assault carrier in combined arms formations. Its design was optimised to survive the massive Syrian

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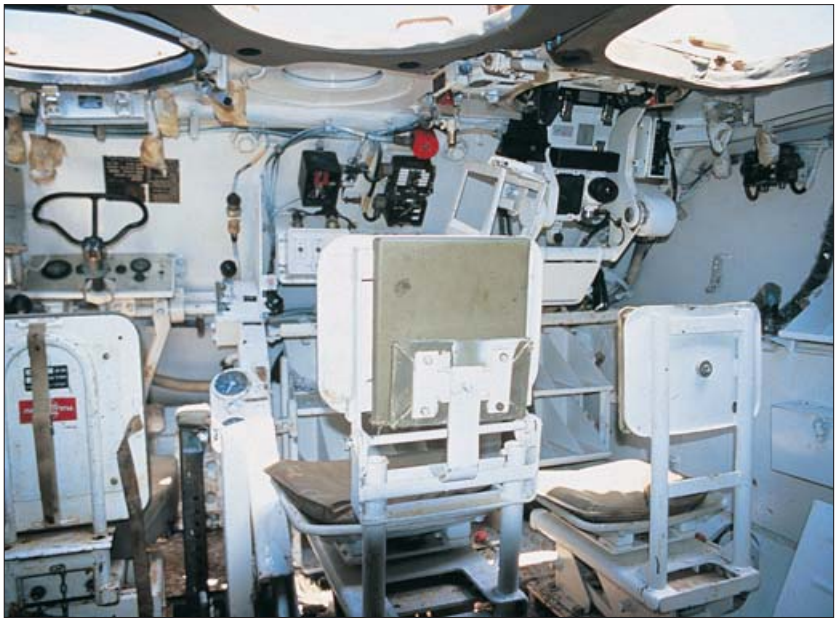
An Achzarit returns to base, Negev desert, 1997. The commander and the gunner are female instructors in training. Note that the Rafael OWS is missing its 7.62mm machine gun.



The interior of an Achzarit, photographed on the Golan Heights in 1997. From left to right are the driver's, commander's and gunner's stations.

defence belts between the Golan Heights and Damascus. However, the Achzarit's active service has been limited to LIC operations, both within the Lebanon and against Palestinian fighters.

During fighting within Palestinian cities in the summer of 2002, many Israeli casualties were caused by snipers firing downwards from surrounding buildings. Machine gunners firing from the hull tops of M113s and other AFVs were particularly at risk. The Achzarit with its OWS was able to fire at Palestinian positions whilst the gunner remained safe under armour. The highest profile of the Achzarit's activities during the Intifada came on Friday, 29 March, 2002. After a bomb explosion in an Israeli supermarket, Achzarits participated in a raid on Palestinian President Yasser Arafat's HQ in Ramallah.

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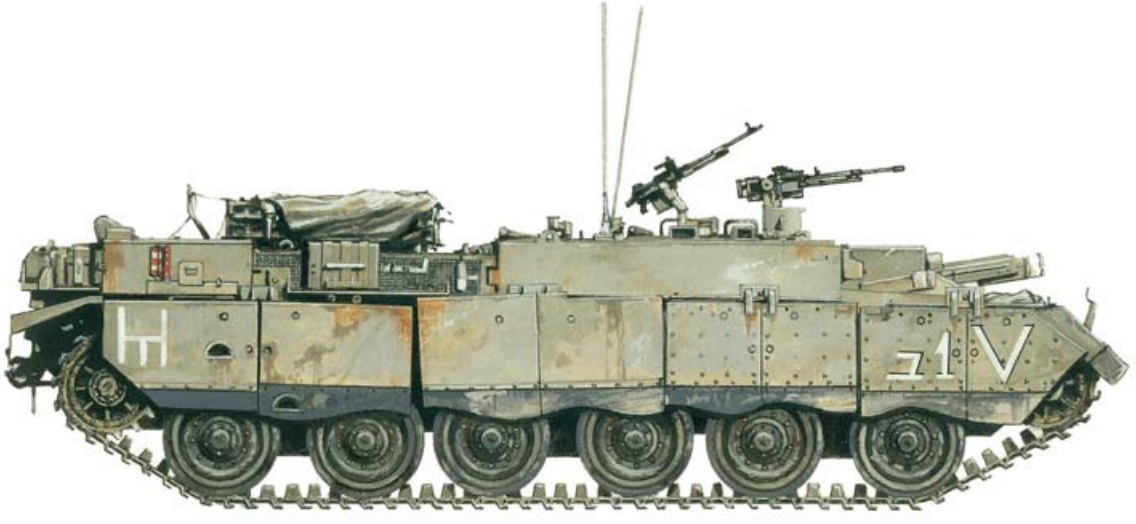
A1: An Achzarit on exercise in the southern Negev desert, spring 1997



A2: Puma combat engineer vehicle, Upper Galilee, 1995

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A tatty, pre-series-production Achzarit photographed in 2002 at Tel ha Shomer ordnance base. These early machines are distinguished by the heavily riveted armour found on their flanks and glacis, and by the fact that they carry two OWS.

Variants

A handful of pre-production machines remain in service. Their main distinguishing characteristic is the heavily riveted armour on their flanks and glacis, typical of Israeli second generation passive armour. In addition they have two rather than one OWS.

There is a command variant of the Achzarit, externally distinguishable by the lack of a Rafael OWS, and the provision of extra communications antennae.

The Puma Combat Engineer Vehicle

Entering service in 1991, the Puma was optimised from the start for the combat engineers and replaced the makeshift Nagmashot. The Puma's configuration is similar to that of the Nagmashot, but with a lower and less bulky fighting compartment. The engine remains rear mounted, so access to the vehicle is via three large roof hatches. The main hatch is for the passenger compartment. Forward of it is the commander's domed Urdan-type hatch, offering all-round vision and overhead protection. The gunner has his own individual hatch adjacent to the commander's. A fourth hatch, situated on the glacis, is for the driver.

A large, open, metal-framed storage basket sits behind the fighting compartment over the engine decking but avoiding the exhaust grille. Two quick-release boarding ladders are mounted on either side of the vehicle, toward the rear of the engine's air intake filters.

The name Puma is actually an acronym from the Hebrew term *Poretz Mokshim Handasati*, literally, 'breakthrough mine engineer vehicle'. The prime function of the Puma is to clear routes through minefields in heavily defended fire zones, giving armoured formations freedom for manoeuvre. To make this possible the Puma is equipped to mount RKM mine rollers. In addition dozer blades are frequently attached to the front of Pumas. The RKM mine roller is based upon the Russian KMT-5 device, but offers better performance. The RKM system consists of twin track-width rollers, each consisting of two banks suspended from pusher bars.

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The rollers use their weight to detonate mines, and a weighted chain which hangs between the rollers is meant to deal with any tilt rod-actuated mines, which might otherwise detonate beneath the belly of the Puma. The suspension arms and rollers are articulated to help dissipate the force of a mine explosion. The rollers take about 15 minutes to fit, requiring two soldiers and a standardised piece of lifting equipment. In an emergency the rollers can be released manually from within the Puma; this takes about 30 seconds.

Pumas can now be fitted with a more modern mine-clearing system using fuel–air explosive. This device, known as Carpet, can either be mounted on the back of a Puma or towed. Carpet can fire up to 20 rockets in a minute. Each rocket releases a fine spray of fuel above the target area, forming an explosive aerosol when it mixes with air. A timed incendiary package ignites the fuel–air mix. When detonated, the resultant blast sets off any mines lying beneath it. Carpet is designed to clear a path 100m long and can be launched from 65 to 165m from the edge of the minefield. All operations, other than reloading, can be carried out from within the protection of the vehicle. It takes two men to reload Carpet. Each rocket weighs some 46kg and is 1.39m in length. The total weight of the rocket pod with its 20 missiles and associated mounting brackets is around 3.5 tonnes. The pod is 3m wide by 2m deep and 1.32m high.

Some Pumas are fitted with an advanced minefield-marking system known as AMMAS. AMMAS is a bolt-on system incorporating drum-like magazines on either side of the vehicle, each stocked with markers. The markers are fired into the ground by telescopic arms, delineating the safe path for following tanks.

Protection

Unlike the Nagmashot, with its Blazer reactive armour bricks, the Puma's survivability is based upon passive armour arrays applied to the glacis and other vulnerable points. Heavy special armour side skirts are standard, these safeguard the running gear. Additional protection is provided by Toga-style, perforated steel mesh around the storage panniers on the Puma's rear flanks. Recently extra armour has been fitted around the driver's station, on the right side of the glacis.

The Puma carries IMI CL-3030 smoke grenade launchers, each fitted with six smoke grenades.

Firepower

Like all the IDF's tank-based carriers, firepower is optimised for use against enemy infantry. MBTs would support the Puma during any breaching operations, taking care of enemy armour. Three 7.62mm machine guns are fitted. Two are mounted on simple pintle mounts and the third on a Rafael OWS. Three roof-mounted 60mm mortars are carried for use against infantry.

Mobility

Early variants of the Puma used the same 750hp power pack as the upgraded version of the Centurion tank which was known as the Sho't. This is the General Dynamics Land Systems AVDS-1790-2A diesel engine and the Allison CD-850-6 transmission. Later Pumas are fitted with the Merkava 1's power pack, incorporating an AVDS-1790-6A engine

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A Puma photographed in 2001, fitted with an RKM mine roller system. Despite the vehicle's bulk, it has a low silhouette. (Nadav Ganot, via the Israeli Government Press Office)

generating 900hp and an upgraded CD-850-6 transmission. Heavy-duty Merkava tracks are being installed on later vehicles.

Although some early vehicles retained the original Centurion suspension. Puma running gear has been upgraded by fitting the independent suspension system of the Merkava 2. This helps the Puma to cope with rugged terrain. The total roadwheel movement of the Puma's new suspension is around 600mm, more than double that of the original fitted and with better shock absorption. The Puma's weight is estimated at 50 tonnes, allowing a rough power-to-weight ratio of 18 hp/tonne. It has a somewhat better reputation for mobility than the Achzarit.

Puma in service

No information has been released by the Israeli authorities as to the Puma's record in combat. It is known that it played a major part in the war against Hezbollah guerrillas in Lebanon.

Within the so-called South Lebanon Security Zone Israeli outposts were widely dispersed, often situated in rough terrain and linked by little more than mud tracks. With their heavy armoured protection, Pumas were used as convoy escorts between IDF strongpoints. They proved useful in clearing mines and widening the roads at choke points where cuttings or overhangs channelled traffic. The Puma was replaced in this role by the slower, but better protected, Nagmachon and Nakpadon LIC carriers.

Although the Puma is optimised for use in more conventional combined arms operations, it saw much service in the Palestinian *Intifada* in the summer of 2002 where its OWS proved useful in urban warfare.

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A Puma at the Eurosatory arms exhibition, June 2002, fitted with a Carpet minefield breaching system. An inert rocket is displayed at the top of the Carpet system module. (Stephan Marks)

A Puma in close up; photographed 1996. The Rafael OWS is shown to advantage, as is the heavy appliqué armour and one of the two smoke grenade launchers. Two heavy duty tow cables are mounted on the vehicle's flanks.

Variants

A small number of Pumas have been converted into armoured recovery vehicles, usually referred to as the Puma RAM. These recovery vehicles have a crane situated over their rear decking.

The Nagmachon and Nakpadon

For 20 years, the Israeli involvement in Lebanon has led to a vicious low-key conflict. At its height in 1995, around 700 attacks were launched on IDF positions and vehicles. These operations were mainly carried out by the Lebanese group Hezbollah. Highly motivated, trained and financed by Iran, Hezbollah was able to inflict a steady trickle of casualties on the IDF. This was politically unacceptable in a society terribly sensitive to military losses.

From the early 1980s onwards the Nagmashot provided the IDF with a heavily protected vehicle useful in cutting down on casualties.

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ABOVE TOP **Nakpadon and Nagmachon Centurion-based carriers photographed in 2000. At the far left the chassis of a Nakpadon carrier with its appliqué armour modules removed can just be seen. The centre AFV is a Nakpadon, that on the right a Nagmachon.**

ABOVE BOTTOM **A Nagmachon carrier missing the ERA tiles which would normally be fitted to its glacis and the gill-like sloping brackets on the side of its fighting compartment. Note two smoke grenade launchers per side and the massively constructed side skirts.**

Subsequently the Israelis introduced improved Centurion conversions specifically designed for LIC operations, the Nagmachon and Nakpadon. The Nagmachon entered service in the late 1980s and the Nakpadon in the early 1990s. Some of these machines were converted from existing Nagmashots, but most were newly transformed Centurions. A handful of early Nagmachons were built upon the hulls of M48 tanks. However, they proved less able to withstand mines and improvised roadside charges than the Centurion-based carriers.

Designed from the start for use in counter-insurgency operations, the Nagmachon and Nakpadon have roomier, somewhat higher fighting compartments than the Nagmashot. As in the case of the Nagmashot, there is no proper rear hatch from which infantry can exit in relative safety. Infantry have to disembark by climbing out of hatches mounted on the upper hull, cross the engine decking and then jump to the ground.

Protection

When compared with the Nagmashot, the Nagmachon carries a more extensive suite of ERA. The Nagmachon is also fitted with exceptionally heavy side skirts. Each full side skirt is made up of seven individual sections, each of which is double hinged, allowing sections to be swung upwards by 180 degrees or forwards or backwards by 90 degrees. This facilitates access to individual roadwheels, without having to remove the whole side skirt. The front four sections of each side skirt are particularly massive and incorporate ERA. The three rearmost segments

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of the side skirts are made of plain steel and are often locked in a vertical position. Carried in such a manner the sections partially protect soldiers when they disembark from the rear of the fighting compartment. The Nagmachon also has improved protection against mines, its underbelly being reinforced.

To increase survivability even further, the Nakpadon uses more sophisticated appliqué armour modules. These are fitted to the glacis, front and flanks of the vehicle's fighting compartment. Their exact composition is unknown. However, IMI has recently released details of its latest bolt-on armour designs; these strongly resemble the modules found on the Nakpadon. The new IMI modules consist of a layer of explosive reactive armour interspersed with layers of steel, rubber and ceramics. They offer protection against Sagger-type anti-tank guided missiles (ATGMs), multiple hits by RPG-7V warheads and 20mm armour piercing (AP) rounds. It can be surmised that the Nakpadon's modules offer at least as much protection.

Like the Nagmachon, the Nakpadon incorporates reactive armour in its massive, corrugated side skirts. The Nakpadon's skirts, which probably incorporate extra layers of ceramic plate, are even thicker than those of the Nagmachon. The sections of the side skirt are individually hinged as those of the Nagmachon. However, the rearmost sections of the Nakpadon's side skirts are not simply made up of steel, but incorporate a layer of extra ballistic protection. Additional belly armour is fitted as protection against mines.

All of the LIC carriers have smoke grenade launchers. The Nagmachon is fitted with four IMI Cl-3030 instantaneous self-screening smoke grenade launchers each equipped with ten grenades. The Nakpadon has just two of these launchers.

Both types of carrier can carry electronic warfare apparatus, intended to block radio signals used to detonate roadside explosive charges. Machines so equipped have a cumbersome transmission mast which towers over their rear engine decking.

Firepower

Unlike the Achzarit and the Puma, the Centurion carriers optimised for guerrilla warfare have not been equipped with an OWS. The main armament for all the LIC carriers is three or four pintle-mounted FN 7.62mm machine guns and at least one 60mm mortar. On occasion machines are fitted with one or more 12.7mm machine guns in lieu of the FN weapons.

In an effort to reduce crew casualties the roof of the Nagmachon's troop compartment is usually fitted with three metal shields, each with ballistic glass vision blocks. The shields allow infantry to fire their machine guns with a degree of safety.

Mobility

Both the Nagmachon and Nakpadon are burdened by excessive weight, the former around 50–55 tonnes, the latter probably weighing 55 tonnes. The Nagmachon retains the upgraded Centurion's 750hp AVDS diesel; the Nakpadon uses the 900hp AVDS 1790-6A power pack of the Merkava 1. The current suspension used by the vehicles is an upgrade of the old Centurion system, incorporating hydraulic bump stops. The running

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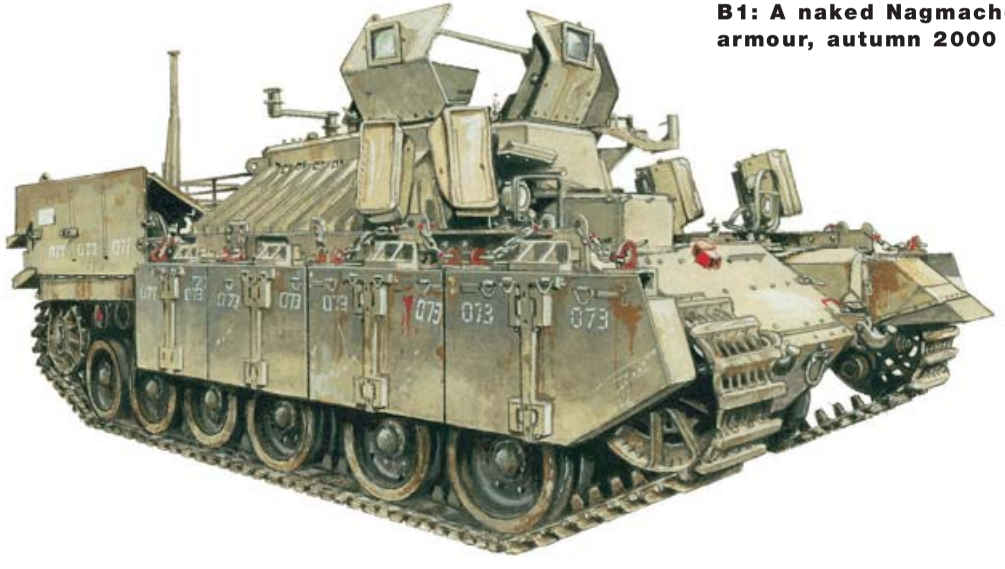

B1: A naked Nagmachon, shown without its reactive armour, autumn 2000

B2: A Nakpadon heavy infantry carrier at Elyakim base, Galilee, autumn 2000

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A Nakpadon photographed at Elyakim base, upper Galilee, 2000. It has a less cluttered appearance than the Nagmachon and its formidable side skirts have a corrugated appearance.

This photo taken in the summer of 2000 shows the thick appliqué armour modules carried by the Nakpadon. Note the vision blocks around the commander's cupola. The thin band painted on the fighting compartment is sky blue.

The front of the Nagmachon, close up. Note the cluttered untidy appearance and the ERA blocks on the glacis. The machine has two smoke grenade launchers in situ. There are empty brackets awaiting the other two launchers.

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A Mifletset, or 'monster', photographed in December 2002 at Tel ha Shomer. The Mifletset is a conversion of the Nagmachon optimised for low-intensity conflicts in urban environments. Crude and ugly, but effective, this Mifletset awaits the fitting of its ERA tiles.

gear of both types of LIC carrier seems to struggle with the excess weight. Roadwheels tend to show signs of severe wear, wheel tyres typically being almost totally destroyed by excessive thermal and mechanical loading. If funds become available, Merkava-style suspension and all-steel roadwheels are likely to be retrofitted.

LIC Carriers in service

The Nagmachon and Nakpadon have been involved in anti-guerrilla operations within Lebanon, carrying out the unglamorous work of convoy protection and mine clearing. When isolated IDF strongpoints have required re-supply, it has been these vehicles which braved the mine-infested tracks. Details of operations have remained classified. However, it is known that Hezbollah was able to destroy a Nagmachon in 1996, using a roadside charge of around 100kg of explosive. Nine Israeli soldiers are believed to have died. The incident involved one of the handful of Nagmachons built on the chassis of an M48.

In 2002 the lack of an OWS limited the machine's usefulness against Palestinian fighters on the West Bank. This is because a high proportion of IDF casualties in urban combat were caused by sniper fire from above. Crewmen firing roof-mounted machine guns on their Nagmachons or Nakpadons proved vulnerable.

Variants

In recent months a bulky, roofed, vertical extension has been fitted to the fighting compartment of some Nagmachons. Sometimes referred to as the kennel, the cumbersome extension is fitted with simple firing ports, Toga screens and vision blocks. Of unsurpassed ugliness, the converted Nagmachon is referred to by troops as the Mifletset (Hebrew for 'monster').

These crudely converted Nagmachons have been used as mobile command posts in urban fighting against Palestinian irregulars.

MAIN BATTLE TANKS

Updating the existing fleet

The Israelis have a long history of upgrading elderly tanks. They were forced into becoming experts at renovating AFVs because political constraints restricted sources of new armour. Even when new tanks became available for purchase, spiralling costs maintained the incentive to modernise existing vehicles.

Updating a tank is not a simple process; upgrading one aspect of a tank often requires that another characteristic receive modification. For instance, if you add extra armour, then you might need to install a more powerful engine to cope with the weight increase. If larger-calibre cannon are retrofitted, then turret drive mechanisms require modification. And whilst protection, firepower and mobility may be paramount, factors such as costs, reliability and maintainability need to be taken into account.

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How are the mighty fallen! Once the backbone of the IDF, this M60, photographed in 2002, is now used as a target on the Golan Heights. The mounting points for Blazer tiles show that the machine was previously rebuilt to Magach 6B standards.

By 1985 the IDF's tank fleet was ageing. Whilst the Merkava was being steadily introduced, they were insufficient in number to replace all the elderly tanks. As we have seen the Israelis made the decision to convert their Centurions into heavy APCs, and also decided to transfer M48s progressively from active service to emergency war reserves. Upgrade efforts concentrated on the 1,300 or so M60s (of various marks) in the Israeli inventory.

Modifying the Magach

The Magach is the name given to the M48 and M60 tanks used by the IDF. The M48s were systematically upgraded after entering IDF service in 1965, making them virtually indistinguishable from the M60s. Early model machines were up-gunned, with licence-built copies of the British L7 105mm cannon, fitted with American-style, vertical breech mechanisms. Additional incremental improvements, implemented for all Israeli main battle tanks (MBTs), saw the introduction of the Urdan low-profile commanders' turret, increased external stowage, thermal sleeves for the cannon, and a 60mm mortar and extra machine guns mounted on the roof. Major changes included a Teledyne Continental AVDS-1790-2A diesel power pack and Blazer reactive armour. The Magach with Blazer is known as the Magach 6B.

By 1985, despite all the upgrades, the Magach was becoming increasingly outclassed by MBTs appearing in the enemy tank fleets. Particularly problematical was the inadequate level of ballistic protection. The turret of a tank is the most likely point to be hit in tank-versus-tank conflict. The thickest part of the M60's turret is 254mm of RHA. Much of

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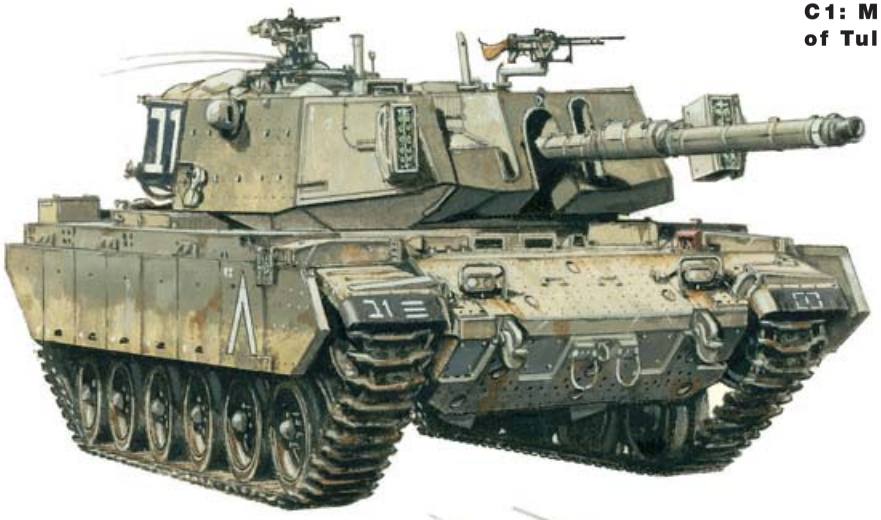

C1: Magach 7A on patrol near the Palestinian city of Tul Karem, July 2002

C2: A Magach 7C on manoeuvres, near the Egyptian border, autumn 2000

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its armour is a great deal thinner. By the 1970s a typical KE round could pierce approximately 400mm of RHA. By the 1990s armour-piercing, fin-stabilised, discarding-sabot (APFSDS) KE rounds fired from 120 and 125mm cannon could penetrate 800mm of RHA.

Blazer kits weighed between 800 and 1,000kg. Against HEAT warheads, they gave a tank the equivalent protection of an additional 10 tonnes of steel. Despite efforts to improve Blazer, including changes to its configuration and composition, it remained inadequate against KE projectiles.

A Magach 7A trundles to the workshop for repair, December 2002. The tracks are in urgent need of re-tensioning. No matter how much the turret profile has been changed by appliqué armour kits, the engine grille betrays the tank's M60 origins.

Adding more RHA would have imposed an unacceptable weight penalty. Lighter, passive materials were required, capable of defeating both HEAT and KE rounds. The IDF decided to borrow from the evolving Merkava project and introduce its new ballistic materials to the Magach upgrades. This process led to major new variants of the Magach entering into service by the mid-1990s.

The Magach 7A

(7 Aleph being the Hebrew designation.) This tank is equipped with passive armour arrays and associated changes to the power pack and running gear aimed at coping with the extra weight. A new fire control system (FCS) is installed.

The Magach 7C

(7 Gimel being the Hebrew designation.) This tank is similar to the 7 Aleph, although its armour is of a later generation.

The Magach 7B

(7 Bet being the Hebrew designation.) This tank was a short-lived interim model between the 7A and 7C. Reputedly only a mere handful of the Magach 7B were built before the 7C, with its better ballistic shaping, supplanted them.

A Magach 7C photographed in the Negev desert, autumn 2000. Note the improved ballistic profiling when compared with the Magach 7A. This machine has been fitted with mounting brackets on its glacis for a bulldozer blade.

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Israeli tanks tend to be modernised in relatively small batches. This is partly owing to cost but also to the need not to disrupt operational capability. Passive armour arrays are expensive and not all Magachs were upgraded with them. Consequently older models of the Magach remained in service alongside newer variants. In November 1997 two Magach 6Bs fitted with Blazer were hit by heavy ATGMs fired by Hezbollah guerrillas. Unlike in 1982, when repeated RPG and ATGM hits had failed to penetrate Blazer-equipped tanks, on these occasions the tanks' armour was breached. The result was one dead loader and five other crewmen wounded. The writing was on the wall. Not only was Blazer ineffective against KE rounds, it was becoming vulnerable to newer-generation HEAT warheads such as that carried by the Spigot ATGM. In 1999 the IDF requested a cheap but effective bolt-on armour package to upgrade the Magach 6B. IMI's response was astonishingly swift. It took only ten weeks from inception to production of the package for what was to be termed the Magach 6 BATASH. (BATASH is an acronym taken from the Hebrew term *Bitachon Shotef*, which means 'overall security').

Protection

Both the Magach 7A and Magach 7C have passive armour arrays capable of coping with most KE and HEAT attacks. The actual combination and configuration of the laminates used in their respective composite armours are classified. The Magach 7A first entered service in the early 1990s, the Magach 7C in the mid-1990s. Both variants of the tank are fitted with add-on armour to the turret, and the front of the hull. Side skirts are also fitted. These are mounted on heavy-duty springs to help prevent them being ripped off when the tank is manoeuvring. The first double panel of the side skirts on each side is made up of passive armour laminates and the others of steel. The passive armour side skirts have a sturdy central hinge allowing access to the running gear.

The Magach 7A has flat-sided, riveted, appliqué armour modules. In comparison, the modular armour kit for the Magach 7C, code-named

A Magach 7C photographed during 2000 in the Negev desert. The heavy, appliqué passive armour modules give the tank its characteristic arrowheaded front profile. The crew wear non-issue baseball caps with an unofficial unit logo of a tank and dragon.

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'Envelope' by its manufacturers IMI, has better ballistic shaping. The arrowhead-shaped turret front of the Magach 7C does, however, make it difficult for the driver to bail out from a burning tank, though IMI made sure that at whatever angle the turret is positioned, the driver can still exit from his hatch.

The Magach BATASH's turret has a hybrid armour package incorporating reactive as well as passive layers. One senior company representative has referred to it as being designed specifically for LIC operations. It is likely that the hybrid package is optimised to protect against multiple heavy ATGM strikes. The glacis of the Magach BATASH is protected by second generation 'Super Blazer' reactive armour tiles. The side skirts are the same as those of the Magach 7.

A Magach 6 BATASH showing off the curved turret lines formed by its add-on armour. The tank is sometimes seen in service without the heavy plate protecting the gun mantlet. (IMI/Slavin, courtesy Shaul Nagar)

Magachs remaining in service are systematically being retrofitted with Moked ('Focus') laser warning systems, which alert the crew if the tank has been 'painted' by a targeting laser. In addition Magachs have been fitted with a fire and explosion suppression system from the Israeli manufacturer Spectronix.

Firepower

The Magach variants retain their 105mm cannon. Improvements have been made to the fire control systems and in the lethality of the ammunition. The turret's hydraulic drive has had to be beefed up to compensate for the weight increase caused by the appliqué armour.

Some Magach 6Bs had been fitted with an improved FCS. The new system was known by the IDF as the Gal (wave), although offered on the international market by its manufacturers Elbit/EL-OP as the Matador. Those Magach 6Bs fitted with the new FCS were known as the Magach 6B Gal. The same Gal FCS was adopted for the Magach 7. The original optical rangefinder has been supplanted by a laser whilst the gunner has new day and night sights. There is a new ballistic computer with associated meteorological sensors and an Israeli-developed thermal sleeve assists gun accuracy. To enhance performance further, the gunner's semi-stabilised sights are slaved to the gun, which is independently stabilised. The commander has his own sights housed in the hemispherical armoured shell on the right turret flank; this used to contain part of the old optical rangefinder system.

Although the actual ammunition load is classified, the Israelis have a good reputation for developing and manufacturing tank rounds. It is likely that the modernised Magachs carry the APFSDS-T M413 kinetic energy round, which is believed to have excellent penetrative capabilities.

Magachs carry a 60mm mortar fitted to the turret roof, for use against enemy infantry.

Mobility

The weight of a baseline M60 is 49.7 tonnes. The Magach 7 variants with their additional armour are thought to be between 54 and 55 tonnes. This weight gain occurred even though Magach tracks were replaced by lighter

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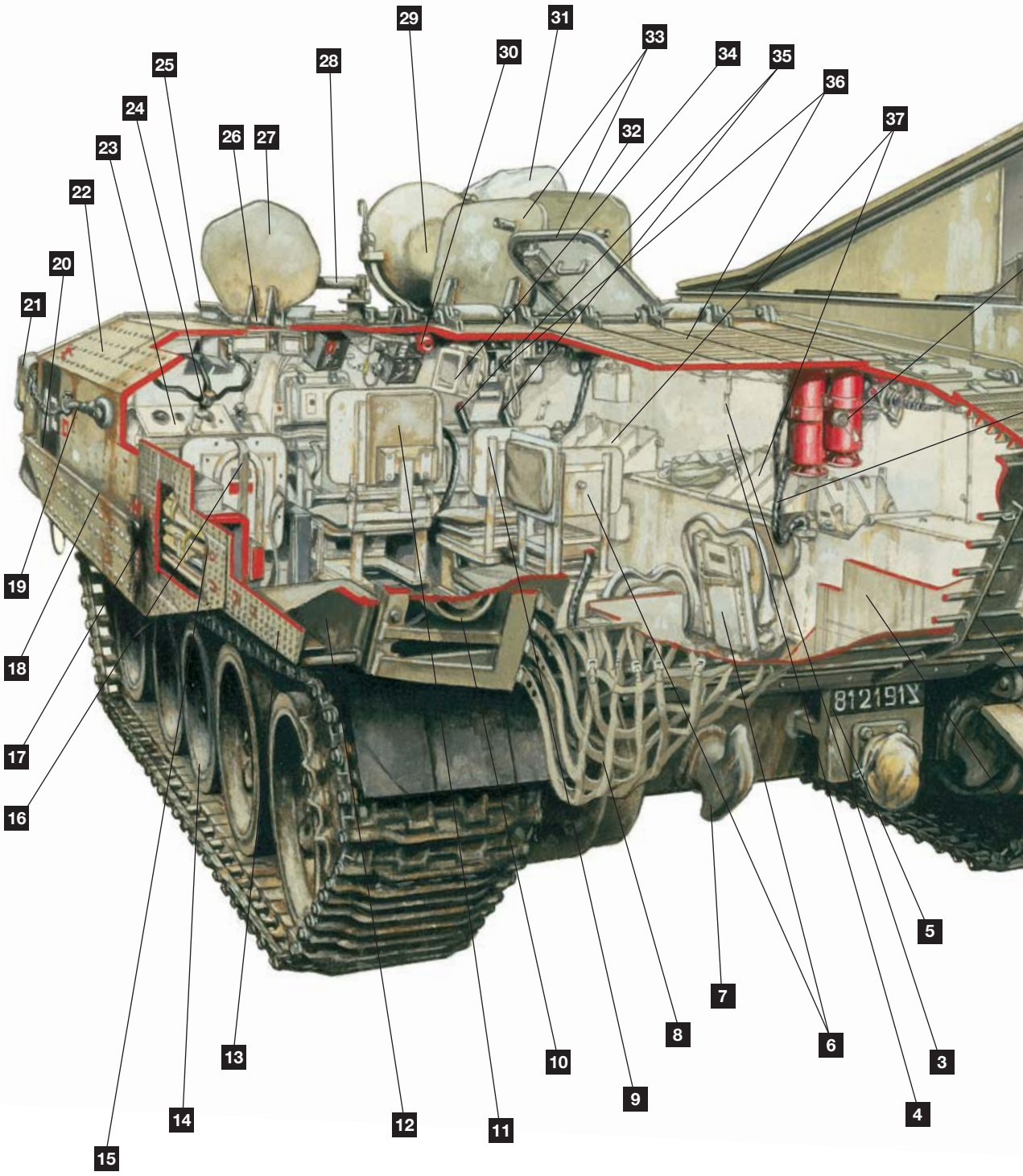

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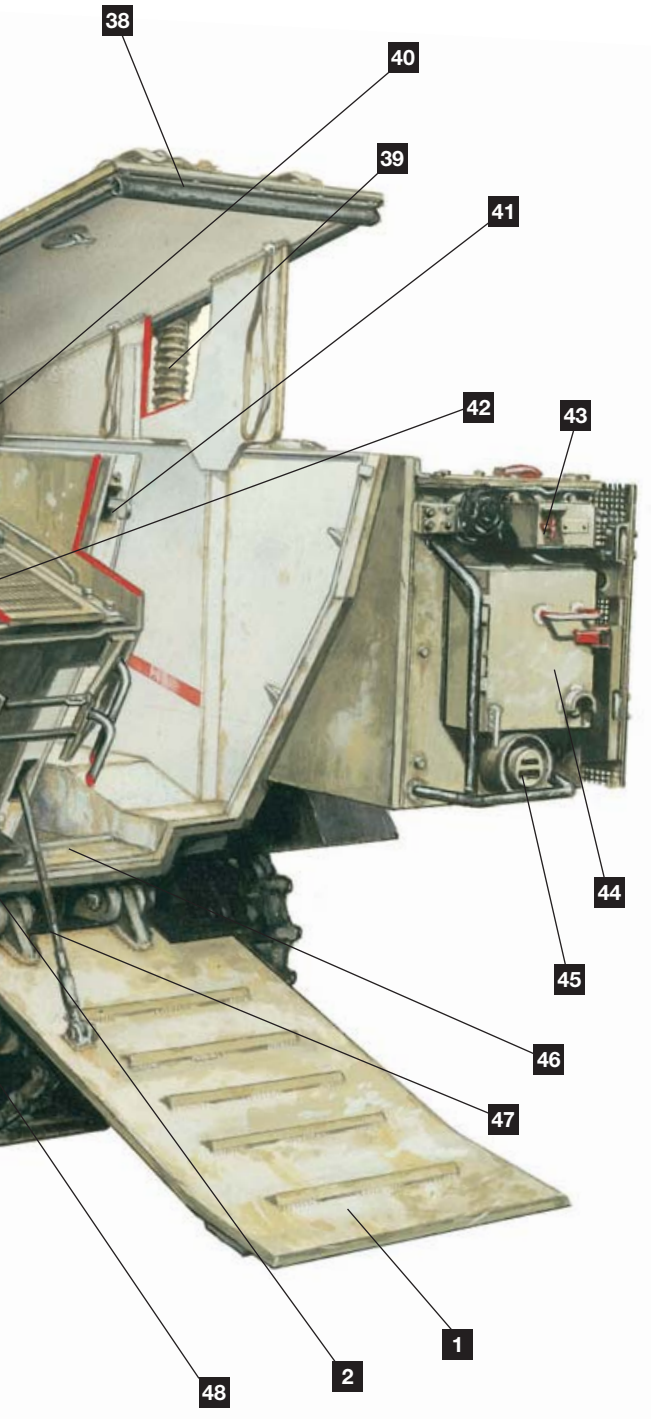

KEY

1. Exit ramp, ridged for better footing
2. Metal bars of hull rear stowage basket
3. Canvas grab handle hanging from vehicle roof
4. Typically grimy, off-white, interior paint scheme
5. Vehicle's registration plate
6. Passenger seats
7. Tow hook
8. Nylon webbing cradle, used to carry further kit below the rear metal stowage basket
9. Gunner's seat
10. Metal grid which protects the rear reflector and anchors stowage basket to hull
11. Commander's seat
12. Space between vehicle's hull and TOGA stand-off armour, used to store kit such as stretchers
13. TOGA perforated steel mesh armour
14. Road wheels
15. Red-painted handle for a hatch accessing storage space behind the TOGA screen
16. Driver's seat
17. Heavy carbon staining by engine exhaust outlet
18. The olive drab camouflage appears lighter through weathering and dust coating
19. Tow cable
20. Black nylon recognition panel with white markings
21. Smoke grenade launcher
22. Bolts and rivets appear on the armour of vehicle's upper side flanks
23. Driver's station
24. Control tiller
25. Exterior portion of a vision block
26. Interior portion of a vision block
27. Driver's hatch
28. Partial view of machine gun's L-shaped mount
29. Commander's hatch
30. Sensor for the vehicle's fire and explosion suppression system
31. The Rafael OWS covered with a nylon bag for protection against the weather
32. Gunner's hatch
33. Passenger hatches
34. Gunner's station
35. Control grips for the Rafael OWS
36. Engine decking
37. Stowage racks for machine gun ammunition
38. Roof of clamshell exit hatch
39. Rubberised concertina covering the hatch's hydraulic mechanism
40. Halon gas storage tanks for the vehicle's fire and explosion suppression system
41. Locking latch for the clamshell access hatch
42. Black corrugated tubing, part of the NBC system
43. Trigger to set off the vehicle's fire-extinguishing system manually
44. Communication box for infantry
45. Rear reflector and light cluster
46. This section of the exit hatch flooring slopes downwards to the vehicle's interior
47. Hydraulic bar to open and close the hatch ramp
48. A partial view of the engine compartment bulkhead. NB - the engine has not been illustrated for the sake of clarity, allowing an uninterrupted view of the vehicle interior

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and more durable all-steel ones, sourced from the Merkava, which saved 1.7 tonnes. Given the weight gain, attention had to be paid to maintaining mobility. The original 750hp power pack was replaced by a 908hp General Dynamics Land Systems Division AVDS 1790-5A diesel coupled with the same automatic transmission as used in the Merkava 1. In addition the Israeli firm Kinetics has carried out some major upgrades of the running gear. New shock absorbers have been fitted to roadwheels one, two and six, along with hydraulic bumpers to roadwheels one, two, five and six. New high-strength torsion bars are now standard. This combination has allowed roadwheel travel to increase from 180 to 200mm. Dissipated energy absorption per suspension station has risen by a very impressive 355 per cent.

In the real world these changes have given the Magach 7A and 7C greatly improved cross-country performance and acceleration when compared with the M60. Crew fatigue is reduced. As hull stability is enhanced, weapon accuracy is also improved.

The Magach 6 BATASH is not thought to have had any major weight gain from its armour package. What weight gain there has been is compensated for by the weight reduction achieved by fitting lighter Merkava-type tracks. Consequently it is unlikely to have been fitted with the more powerful engine.

Modified Magach in service

The post-1985 upgraded tanks have seen combat, not against enemy armour, but in the bitter fighting against Hezbollah and Palestinian guerrillas. The tanks have in effect been used as mobile pillboxes, making use of their relative invulnerability and sophisticated sensors to cut back on casualties.

The Magach's extra armour has proved literally a life saver. In autumn 1997 a Magach 7A was reported to have been hit by salvos of Sagger missiles, in an ambush launched by Hezbollah guerrillas. Twenty Saggers hit the tank, two of which, fired downwards from hilltop positions, actually penetrated it. Israeli operational analysis determined that with an appliqué suite of Blazer rather than passive armour, nine warheads would have penetrated. However, not even the better-protected Magach 7C could

The turret roof of a Magach 7C looking at the commander's Urdan low-profile cupola, 2000. The 60mm mortar can be seen to the left of the cupola, above the hemispherical mounting for the commander's sights. In the centre foreground a disc engraved with three lines may just be seen on the turret. This indicates third generation armour modules.

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cope with the massive roadside charges that both Hezbollah and the Palestinians have started to employ. On 15 February 2003 four soldiers were killed, and their Magach 7C destroyed, when it ran over a roadside charge in the Gaza Strip. The charge, according to the Israelis, weighed 100kg. No tank could withstand such an attack against its weak underbelly.

Little is known about Magach BATASH operations other than that the type saw action in the West Bank during the Palestinian *Intifada* of 2002–3.

This is the Sabra, an export version of the Magach 7, photographed in 2000 whilst on trials. The Sabra is fitted with a 120mm cannon and has had some re-profiling performed on its arrowhead turret. Turkey is the lead customer for this tank. It is unlikely to enter IDF service. (IMI)

Variants

As new armour technologies become available, the modular nature of the add-on armour kits will allow further minor upgrades to the Magach. For example, some Magach 7Cs have been seen in 2003 with extra armoured panels added to the front of the turret roof.

Whilst it is unlikely that the Magach will be developed much further in IDF service, an extensive upgrade package has been sold to Turkey based upon the Magach 7C. The upgraded tank, known as the Sabra, has some fine tuning of its ballistic profile, and an IMI 120mm cannon. The cannon's compact breech has allowed the larger weapon to be fitted with minimal alterations to the tank's mantlet.

The 1973 war had exposed a design flaw in M48 and M60 tanks. Their turret traverse and gun elevation are powered by high-pressure hydraulics. If the tank was pierced, the hydraulic system often fractured, spraying the crew with a flammable liquid which often ignited. In contrast the all-electric turret drive of the Centurion proved slower but safer. In the wake of the 1973 war, a liquid with a higher flashpoint was employed for the Magach's turret hydraulics. In the case of the Sabra, a more satisfactory solution, the fitting of an all-electric turret drive, was achieved.

The Modular Merkava

The development of Israel's unique Merkava ('Chariot') tank is well covered in Osprey New Vanguard 21, *Merkava Main Battle Tank Mks I, II, & III*, by Sam Katz.

The Merkava project incorporated, from the start, a vigorous programme of incremental improvements to the tank's survivability, firepower and mobility. As soon as new technologies became available they could be included in new-build machines and retrofitted to older models of the Merkava. The upgrades are part of an ongoing, rolling process. The constant renovation of IDF armour blurs the distinction between different variants of the Merkava. Indeed the same can be said of other upgraded tanks in IDF service. Making a hard and fast distinction between different models of a particular tank is not as cut and dried in the IDF as in other armies.

This section of the book examines modifications and upgrades to the Merkava, classified when New Vanguard 21 was published in 1997. The primary changes are the introduction of highly sophisticated fire control systems and fourth generation add-on armour modules.

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RIGHT **A Merkava 3 photographed on the Golan Heights in 1995. The wedge-shaped turret presents a small target when seen from the front.**

BELOW **A Merkava 2 being upgraded at Tel ha Shomer ordnance base, December 2002. Note the hefty mounting points on the turret flanks used for fitting the add-on armour and the new storage panniers on the side of the turret bustle.**

Merkava 2B Dor Dalet

The Merkava 2 B Dor Dalet (*Dor Dalet* literally means 'generation D') is the Merkava 2 as described in Osprey's New Vanguard 21, but with an improved fire control system and much enhanced levels of protection.

Protection

The Merkava is unique amongst MBTs as it has its engine mounted in the front. A Merkava crew has a greater chance of survival than that of a tank with a conventional configuration. If a Merkava is hit over its frontal arc and is penetrated, the power pack acts as an extra barrier protecting the crew. The Israelis would rather their tanks suffer a mobility kill than lose vital trained crewmen. The Merkava's rear exit hatch also makes bailing out less hazardous, the crew being less exposed to small arms fire than they would be exiting from the turret hatches.

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E1: Merkava 2 with fourth generation armour alongside the Lebanese border, 23 July 2000

E2: Magach 6B BATASH in action on the West Bank, summer 2002

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A Merkava 2 Dor Dalet, photographed *circa* 1998. This is thought to be the manufacturer's proof-of-concept vehicle. (IMI/Slavin, courtesy Shaul Nagar)

The initial model of the Merkava 2 had better protection than the Merkava 1. As in all models of the Merkava, the shape of the tank's rear turret acts as a potential shot trap. To counter this, balls and chains were hung from the turret rear to protect against HEAT rounds. In addition, the Merkava 2 had special armour layers attached to the glacis and turret sides, whilst heavy special armour side skirts were fitted to protect the running gear. However, by the late 1990s Hezbollah had achieved access to modern ATGMs with tandem warheads. These were capable, in certain circumstances, of penetrating the armour of the Merkava. In autumn 1997 a Merkava 2 was hit by a Spigot anti-tank missile, directly above the driver's compartment at the junction of the hull and turret. The driver was killed. This caused the IDF a considerable shock, as previously the tank had been considered almost invulnerable to HEAT attack. By the middle of October 1997 two other Merkava 2s had been hit by Spigots and knocked out, one crewman dying. A task force under General Israel Tal, the guiding light of the Merkava project, was set up to help prevent any recurrence. In a crash programme of just 14 weeks, IMI was able to design and produce new bolt-on fourth generation armour packages that were proof against both kinetic energy and heavy HEAT rounds.

In the Merkava 2 Dor Dalet, these packages have been attached to the slopes of the upper glacis of the tank, protecting the driver's compartment, flanks of the turret and the side skirts. The turret sides have lost their flat-sided appearance and now have fourth generation modular armour lobes which sweep down to the base of the turret, protecting the junction of turret and hull. The side skirts, also made up of special armour modules, extend upwards. The extensions provide further protection to the turret ring and give the tank a distinct hump- backed profile.

Firepower

The Merkava 2 is equipped with the Israeli-manufactured 105mm cannon, with thermal shrouds, the same as fitted to the Magach. The FCS of the Merkava 2 is known as the Matador Mark 2. It is an update of an earlier model equipping the Merkava 1, but with a better digital computer and an improved laser rangefinder.

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A Merkava 2 Dor Dalet, photographed in 2000 with Merkava 3s in the background. The add-on armour modules give a sleek silhouette. Note the heavy slab of armour protecting the driver's station. (Moshe Milner, courtesy of the Israeli Government Press Office)

The Merkava 2B introduced a thermal imager to the gunner's sights giving better performance at night and in poor weather conditions. The Merkava 2B Dor Dalet uses the same FCS.

Mobility
The engine of the Merkava 2 is the same as that of the Merkava 1, the 900hp General Dynamics Land Systems AVDS-1790-6A diesel. An improved, Israeli-manufactured, fully automatic transmission, has been fitted. This gives the tank an increase in range. At 900hp the power pack is relatively under-powered for a tank weighing some 62 tonnes. However, the IDF is more concerned that the tank's suspension and ride are able to cope with the rough terrain typical of the Golan Heights. The Merkava 2 can climb slopes of 70 degrees gradient rather than the 60 degrees usually managed by other tanks. All variants of the Merkava 2 use the same power pack.

Merkava 2B Dor Dalet in service
Information is restricted. The tank appears to have been used with success in the Lebanon and has also played a role in opposing the Palestinian Intifada.

Variants
No variants are known.

Merkava 3 Baz

The Merkava 3 has been built in a number of production blocks, each block having some improvements over its predecessor. Blocks I and II have minor internal changes. The Block III Merkava, sometimes known as the Merkava 3B, is distinguished by an additional layer of special armour on the turret roof, a reshaped loader's hatch and a modified mounting for the 60mm mortar. Some newer build Merkava 3s have been fitted with an improved NBC protection system which offers intergrated air conditioning. The system can supply chilled air to environmental vests

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worn by the crewmen. Merkavas with the new NBC system have larger air intake grilles on the hull. When improved further with a new highly sophisticated FCS, the tank is known as the Merkava 3 Baz. *Baz* is the Hebrew for 'falcon', although in this case it is an acronym taken from the words *Barak Zoher* ('Shining Lightning') the name of the FCS. The Baz FCS is being retrofitted to earlier blocks of the Merkava 3.

The most advanced variant of the Merkava 3 Baz is fitted with fourth generation armour modules, and is known as the Merkava 3 Baz Dor Dalet. The modules around the flanks of the turret give the tank a futuristic profile different from those of 'lesser' Merkava 3s. The tank's appearance is reminiscent of the Merkava 2 Dor Dalet.

Protection

Third generation armour modules, incorporating passive laminates, are standard for the Merkava 3. These are fitted to the tank's turret and glacis. These are easily replaceable if damaged, or when more advanced composites become available.

Work on the first major armour upgrade commenced in earnest in June 1994. This was after a Merkava 3 was hit by a score of ATGMs, three of which penetrated the upper surfaces of the turret and hull. IMI switched emphasis from protecting the tank's frontal arc, where the Merkava was already exceptionally well armoured, to protecting its upper surfaces. The result was the Merkava 3 Baz Dor Dalet. This variant, with its fourth generation armour modules, has increased protection for its turret, upper hull and turret ring.

All Merkava 3s are fitted with an Ancoram laser warning system incorporating three sensors which give 360-degree coverage. The system lets the crew know when they have been 'painted' with targeting lasers.

A refitted Merkava 3 photographed at Tel ha Shomer in December 2002. The arrow indicates the independent commander's sight, signifying that the tank is fitted with the Baz fire control system.

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To limit the chance of blowing up if hit, all Merkavas are fitted with Spectronix fire detection and suppression systems. In addition, ammunition rounds are stowed in individual fireproof containers to prevent them from detonating. An all-electric turret drive helps minimise chances of fire.

Ambushes involving mines and roadside charges have proved a growing danger for Israeli armour. The Merkava has a hollow V-shaped belly plate to help reduce blast damage. Unlike other tanks with a similar device, the Merkava's belly is protected by bending a single plate rather than the cheaper method of welding two together with the potential weak point that entails. Merkavas also have a second thinner belly plate mounted internally. The space between is used as a fuel tank in the Merkava 1 and 2. In the Merkava 3 the space is air filled; air transmits shock waves less readily than liquids. An additional add-on belly plate is available, but this tends not to be fitted as it restricts ground clearance.

ABOVE **A Merkava 3 Dor Dalet photographed near Nafach on the Golan Heights, December 2002. The fourth generation appliqué armour completely changes the turret profile. The machine gun, mounted over the cannon mantlet and used for sub-calibre training, is missing its barrel.**

BELOW **A Merkava 3 Dor Dalet mounted on a low loader on the Golan Heights, December 2002. It is thought that this tank belongs to the Barak Brigade, one of the IDF's premier units.**

Firepower

All Merkava 3s carry an Israeli-manufactured smoothbore 120mm cannon fitted with a thermal shroud. The commander and loader have their own turret-roof-mounted 7.62 mm machine guns. A 12.7mm weapon can be mounted over the cannon mantlet and is used for training purposes and in urban fighting. As in all IDF tanks, a 60mm roof-mounted mortar is also carried for use against enemy infantry.

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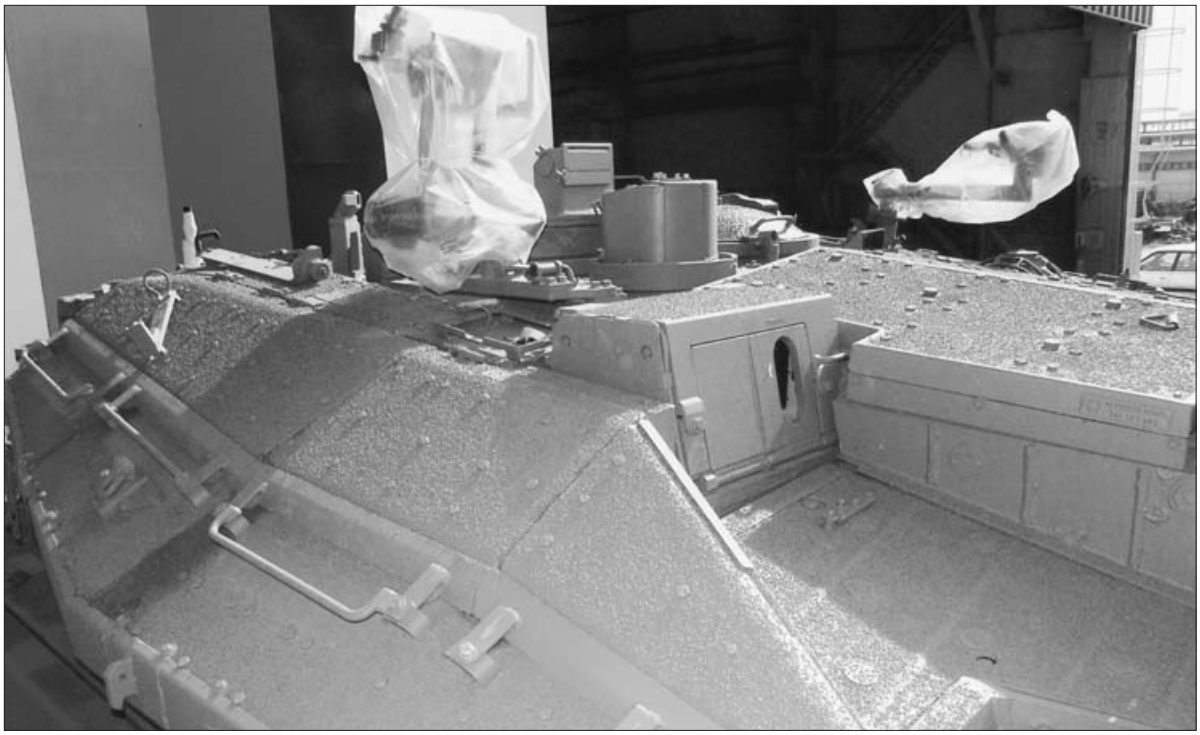

A close-up of the Merkava 3's turret fitted with appliqué fourth generation armour, photographed in 2002. The turret armour has a textured, non-slip surface and a stepped appearance. Note the independent commander's and gunner's sights.

The Merkava 3 Baz has improved accuracy when compared with earlier variants of the tank. The gunner's sight is independently stabilised with a laser rangefinder and has a day channel with x12 magnification plus a thermal imaging sight with x5 magnification. The Baz FCS incorporates an auto tracker, which locks on to moving targets even when the Merkava itself is moving at speed. The tracker predicts the movement of targets and relocks on those that have been temporarily obscured by terrain. In combination, the sophisticated FCS and auto tracker enable conscript crews to obtain very high gunnery accuracy. Such is the speed of the auto tracker, it enables the tank to target and engage helicopters.

The Merkava 3 Baz Dor Dalet has the same FCS, but with the addition of separate, stabilised independent sights for the commander. This allows the tank to operate more efficiently in the hunter–killer role. The independent commander's sight is being retrofitted to earlier variants of the Merkava 3 Baz.

The Merkava 3 Baz has a horizontal semi-automatic, drum-shaped ammunition cassette mounted on the tank's floor. This contains five ready rounds and helps reduce the loader's workload. The tank can fire the usual IMI kinetic energy and HEAT rounds as well as flechette rounds for use against infantry and soft-skin vehicles. The latest model IMI HEAT rounds, unlike others on the market, are equipped with flip-out fins. These greatly enhance accuracy.

Mobility

It is often said that the Merkava is under-powered. At first glance, if you compare the Merkava 3 with the US M1A2 Abrams, this appears to be the case. The Merkava 3 Baz weighs almost 65 tonnes. Its AVDS-1790 power pack produces 1,200hp, giving a power to weight ratio of approximately

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18.5hp/t. The M1A2 weighs 63,086kg; its Textron Lycoming turbine generates 1,500hp, giving a power to weight ratio of 23.77hp/t. However, initial impressions are misleading. There is no doubt that the Abrams will accelerate more swiftly and will be quicker over good, flat terrain. Yet, to the surprise of the Americans, comparative trials saw very little difference in capabilities between the two tanks when they moved cross-country. Nor was there much discernible difference between the tanks as far as actual usable power is concerned.[1] The reasons are twofold.

When crossing rough ground the main limitation to fast manoeuvre is not horsepower, but the ride tolerance of the crew. Under these circumstances the Merkava's sophisticated suspension system allows it to more than hold its own. The Merkava's roadwheels have a greater range of vertical movement, at 604mm bump and rebound, than those of its competitors. In combination with its excellent shock absorbers, this allows the Merkava to move faster over rough terrain than other modern MBTs without causing injury or discomfort to its crew.

In the real world, the efficiency of the transmission has a major influence on mobility. The Allison transmission of the M1A1 is able to deliver approximately 1,000hp of its 1,500hp output to the drive sprockets. Despite the notably lower horsepower produced by the Merkava's engine, its transmission, made by the Israeli company Ashot, can deliver within 20hp of the M1A1's figure.

All the Merkava 3s have the same basic power pack and transmission. From the Merkava 3 Baz onwards, modifications to the engine mean that there is an extended time in between overhauls. The Merkava 3 Baz Dor Dalet has been fitted with all-steel suspension units and roadwheels. This has led to increased durability and reduction in thermal signature.

Merkava 3 Baz in service

The Merkava 3 Baz entered service in 1995. The Merkava 3 Baz Dor Dalet entered service in 2000, joining the Barak Brigade, a unit which vies with the 7th Brigade for the title of Israel's premier armoured unit.

Four Merkava 3s, the actual types are classified, have been lost whilst patrolling around Gaza. They were all destroyed by roadside charges ranging from 50 to 100kg. The first was hit on 14 February 2002, the second on 14 March 2002. Two more were lost to improvised mines in February 2003.

Variants

The modular nature of the Merkava 3's armour packages makes future upgrading of the MBT very likely. The only major variant that has been declassified is a prototype armoured recovery vehicle based on the Merkava 3, with its turret removed and replaced with a crane.

The future is here – The Merkava 4

In June 2002 the IDF unveiled its latest tank, the Merkava 4, a bulky beast with the same configuration as earlier marks of the tank. A major difference from earlier models is that the Mark 4 is fully digitalised. Vehicle electronics, sensors and computers are all integrated, increasing the tank's fighting abilities.

1 See the letter by Maj Gen Stan R. Sheridan in Armor, Vol. CVIII No. 6, November–December 1999; p. 3.

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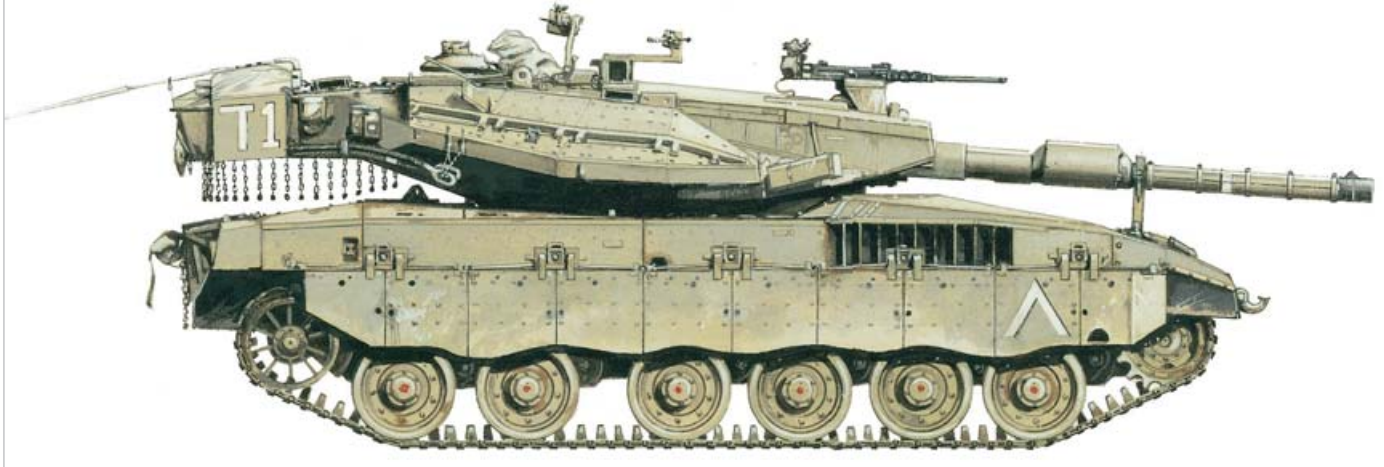
F1: Merkava 3 Baz Dor Dalet awaiting inspection at Tel ha Shomer ordnance base, December 2002

F2: Merkava 3 Baz Dor Dalet of the Barak Brigade, as photographed at Nafach junction on the Golan Heights, December 2002



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A Merkava 4 photographed in 2002. Of interest is the circular indentation to the top right of the turret; this is where the commander's sight has been temporarily removed. (Evgeny Nesher)

Protection

The modular armour fitted to the Merkava 4 is thought to incorporate both active and passive elements. The surface of the armour is notable for the mass of bolts and rivets that mark its surface. As ATGMs are increasingly being designed to target a tank's relatively thin roof armour, much thought has been given to protection against overhead attack. The loader's turret hatch has been deleted; the Merkava 4 is the first contemporary tank to do without one. The reason the hatch has been removed is that apertures in the turret roof compromise protection levels.

An advanced electromagnetic warning system is standard. Currently the tank has banks of smoke grenade launchers, used to obscure its position if it has been painted by enemy targeting lasers. In the future a more comprehensive, active defence system could be fitted. This will be capable of detecting enemy ATGMs in flight and launching projectiles to neutralise them.

As in all Merkavas from the baseline Mark 3 onwards, an overpressure NBC protection system is fitted. Crew comfort is enhanced, as the Merkava 4's NBC system also provides individual air conditioning to crew stations.

Firepower

The tank carries an improved, locally-produced, 120mm smoothbore cannon. The weapon can handle higher ballistic pressures than other 120mm cannon in service; this allows increased muzzle velocity for KE rounds giving superior killing power. The usual types of KE and HEAT rounds are carried. Flechette rounds and a dual purpose anti-personnel/anti-material round are provided for use against soft targets. A new semi-automatic magazine, taking 10 ready rounds, has been fitted to assist the loader.

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The Merkava 4 has a cutting-edge FCS. The commander and gunner have fully independent and stabilised sights with advanced thermal imaging. Target acquisition and destruction is facilitated by a highly developed version of the Baz auto tracker.

A sophisticated battlefield management system, manufactured by Elbit, is built in to the tank. This amalgamates information from electrical and optical sensors, navigational equipment and communication devices. The data is shown on flat-panel colour screen displays, allowing the crew to access and assimilate information more quickly. The battlefield management system gives the Merkava 4 crew better situational awareness. Real time data is shared not just among individual crewmen but between tanks. Integrated vehicle electronics mean that the tank commander can get within an enemy's decision-making cycle. Targets can be acquired and destroyed before they can react.

The advanced FCS and sensors facilitate the use of a new cannon-launched missile, the LAHAT. The LAHAT is a long range precision weapon that uses semi-active laser homing. The LAHAT round is less than 1m long, roughly the size of a standard tank round, but with twice the usable range. LAHAT can be fired against both tanks and attack helicopters. The missile flies a lofted top-attack profile when launched against MBTs, targeting the vulnerable top surfaces of enemy armour. It flies a flat trajectory when fired against helicopters. The tank firing the missile can designate the target, or if the target is out of line of sight, it can be designated by another tank. This increases tactical flexibility.

The Merkava 4, photographed in 2002, has a formidable appearance and large battlefield signature. The armour has a 'pockmarked' riveted appearance. Note the new-style smoke grenade launchers and the pop-up driver's lights in their armoured housing. (Evgeny Nesher)

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The considerable bulk and height of the Merkava 4 can be gauged by the soldiers by its side, 2002. The purpose of the heavy-duty antennae, one by the front of each side skirt, is unknown. (Evgeny Nesher)

The LAHAT can be used by Merkavas with either 105mm or 120mm cannon. The missile has a calibre of 105mm, but can be adapted easily to allow firing from the larger-calibre weapon.

Mobility

The 65-tonne tank has a new 1,500hp German power pack, the GD833, produced under licence in the USA by General Dynamics. It also has a new Renk RK325 automatic transmission. The tank's suspension system is an upgrade of that of the Merkava 3. The IDF has specified that the tank should be capable of traversing rough terrain at a speed of 60km/hr with minimal crew discomfort or systems breakdown.

The Merkava 4 has four cameras embedded in the tank's armour. These give the driver all-round vision, including former blind spots to the tank's sides and rear, on a high-resolution monitor. The driver can carry out his duties more easily, even when driving buttoned down.

The Merkava 4 in service

After gruelling pre-service trials, the machine officially went into production at the end of January 2003. The machine will slowly enter into full service as funding allows.

Variants

There are no known variants, but if financial resources allow, the tank hull will provide the basis of a new heavy APC.

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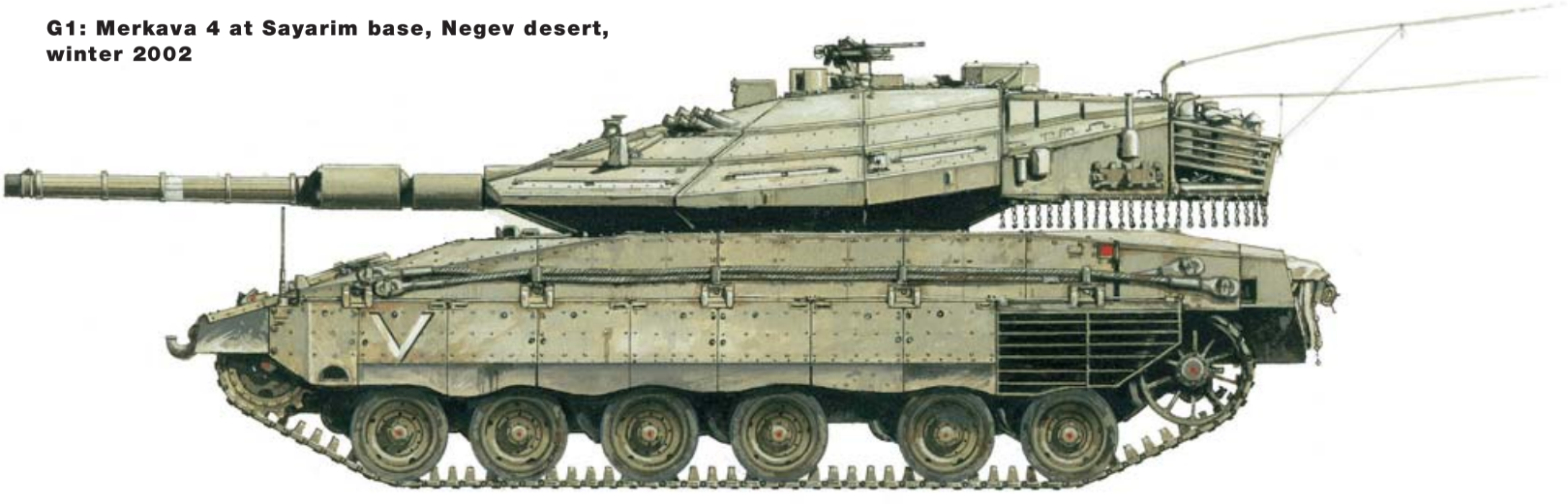
G1: Merkava 4 at Sayarim base, Negev desert, winter 2002



G2: Merkava 4 from the front, autumn 2002

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CONCLUSION

The Israelis have engaged in 20 years' worth of intensive effort, which has seen them introduce highly survivable infantry carriers and combat engineer vehicles. At the same time, and despite a restricted budget, they have stretched the capabilities of elderly tanks beyond the manufacturer's expectations. Whilst carrying out the above tasks, they have introduced upgrades to their indigenous tank designs, culminating in the Merkava 4, perhaps the most modern MBT in service anywhere. In combination, these achievements are highly impressive.

GLOSSARY

AFV Armoured fighting vehicle
APC Armoured personnel carrier
APFSDS-T Armour piercing, fin-stabilised, discarding-sabot – **tracer**; a type of kinetic energy ammunition
ATGM Anti-tank guided missile
Blazer A type of explosive reactive armour
ERA Explosive reactive armour
FCS Fire control system
HEAT High explosive anti-tank round or warhead
IDF Israel Defence Force
IFV Infantry fighting vehicle
KE Kinetic energy round, a high-speed, high-density dart
LAHAT An Israeli ATGM round launched from a tank cannon
LIC Low-intensity conflict
MBT Main battle tanks
NBC Nuclear bacterial chemical
OWS Overhead weapon stations
Passive armour Composite or laminated materials with excellent ballistic properties
RHA Rolled homogeneous armour; made of steel plate
RPG Rocket-propelled grenade
Sagger NATO codename of a first generation Soviet/Russian anti-tank guided missile
Spigot NATO codename of a second generation Soviet/Russian anti-tank guided missile

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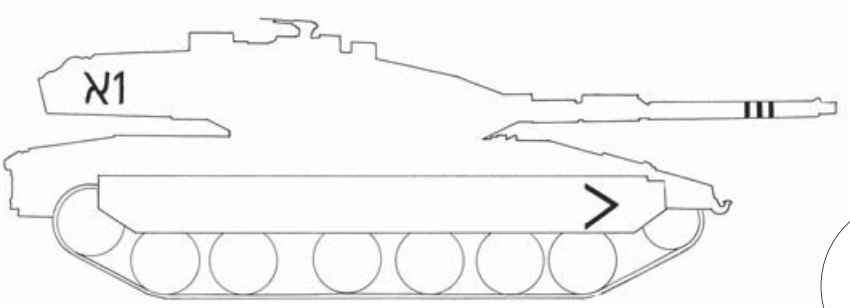
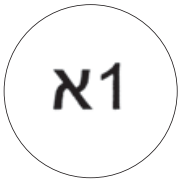
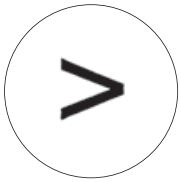
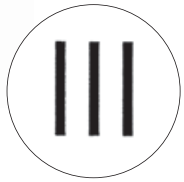
ISRAELI TANKS – TACTICAL MARKINGS





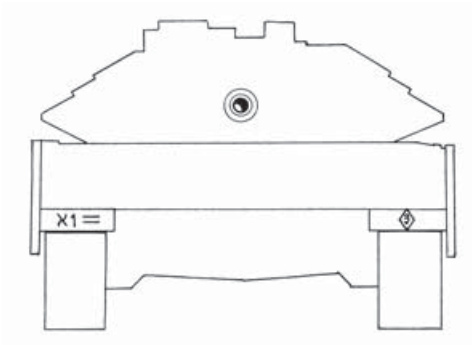


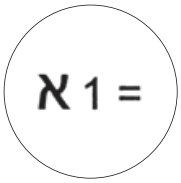


1 Platoon markings in white appear on the turret sides. They consist of the Hebrew alphabetical character Aleph, Bet, Gimel or Dalet, and a number. The character indicates the tank's designation within the platoon; the number indicates which platoon. The markings show this is Aleph tank of 1st platoon.

2 Company markings consist of white chevrons and are found on the side skirts of tanks. V indicates the tank is in the 1st company; > indicates the 2nd company; ^ indicates the 3rd company; < indicates the 4th company. This tank belongs to 2nd company.

3 Battlion markings appear as white barrel rings. These designate which battalion of the parent brigade the tank belongs to. A single white ring indicates 1st battalion, two rings 2nd battalion, three rings 3rd battalion. This tank belongs to a 3rd battalion.





4 Cluster markings in white showing platoon and company information are meant to be displayed on the tank's front and rear fenders, but are often omitted or obscured by dust and dirt. The markings repeat information found on the vehicle's side and show the tank's company, platoon, and designation within the platoon. Instead of the spinning chevron found on the side skirts, the company marking is represented here by parallel horizontal lines; one for 1st company, two for 2nd company, and so on.

5 Cluster markings in white showing battalion and brigade information are meant to be displayed on the tank's front and rear right fenders, but are often omitted or obscured. The meaning of cluster markings on the right fenders is not fully deciphered. They consist of a number inserted within a stylised stencilled shape; typical ones are diamonds, five pointed stars, crescents or boxes. The number 3 corresponds to the tank's barrel marking and is thought to denote the battalion. The shape is thought to correspond to the identity of the parent brigade.

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COLOUR PLATE COMMENTARY

A1: AN ACHZARIT ON EXERCISE IN THE SOUTHERN NEGEV DESERT, SPRING 1997

The low-slung Achzarit was designed to transport infantry through the formidable defence belts that the Syrian Army has constructed between the Golan Heights and Damascus. As portrayed here, its characteristic rear clamshell exit is in a raised position.

The Achzarit's Rafael overhead weapon system provides a useful capability against enemy infantry. The gunner can either fire the weapon remotely from under armour, or directly, with his head and shoulders exposed.

Typically this Achzarit shows evidence of hard use. Its roadwheels demonstrate considerable wear and tear, whilst the engine exhaust, above the fourth roadwheel from the left, has heavy carbon staining around it.

The Achzarit seldom carries any permanent tactical markings other than its registration plate. As required, temporary tactical markings can be applied along the vehicle's flanks. The vehicle's olive drab colour scheme is overlaid with a patina of desert dust.

A2: PUMA COMBAT ENGINEER VEHICLE, UPPER GALILEE, 1995

The machine illustrated belongs to a combat engineer unit which regularly patrolled within the Israeli-occupied part of South Lebanon. The Puma proved well suited to the job, being kitted out with add-on passive armour. Note the heavy special armour sections which make up the front of the side skirts.

The Puma portrayed has typical markings; the leftmost symbol is that of the *Handasa Kravit* or Combat Engineers. The Hebrew letter Bet and numeral 1 indicate that the machine is vehicle B of the first platoon and the chevron pointing downwards shows the machine belongs to its battalion's first company.

The machine is painted in the standard Israeli olive drab, a colour which appears to change shade subtly according to light and weather conditions.

B1: A NAKED NAGMACHON; SHOWN WITHOUT ITS REACTIVE ARMOUR, AUTUMN 2000

The Nagmachon is a Centurion-based 'Kangaroo carrier', optimised for use in low-intensity conflicts. This example is particularly war weary, in need of a repaint and repair to its worn-out running gear. The vehicle is painted in the olive drab typical of most current IDF vehicles. Like all Nagmachons the vehicle's exterior has a cluttered and untidy appearance.

Note that this Nagmachon has not had its appliqué reactive armour blocks fitted yet. These would be mounted on to the glacis and the front of the fighting compartment. As can be seen here, reactive armour modules can also be slotted into the gill-like ridges seen along the vehicle's flanks. Each of the special armour side skirts has a number identifying the parent vehicle stencilled on it. The number is usually taken from the last three digits of the registration plate.

Dependent on the expected threat levels, some of the appliqué armour is sometimes omitted. This is done in an attempt to reduce weight and thus improve mobility.

B2: A NAKPADON HEAVY INFANTRY CARRIER AT ELYAKIM BASE, GALILEE, AUTUMN 2000

Elyakim base is where Israeli soldiers allocated patrol duty along the Lebanese border train for anti-guerrilla operations. As part of the training schedule, IDF infantry acquaint themselves with heavy infantry carriers. The latest of the Centurion-based carriers is the Nakpadon low intensity conflict carrier.

This Nakpadon shows its massive side skirts to advantage. The front panels of the side skirts can be swung inwards to allow access to the vehicle's running gear. The rear panels of the side skirts are of a lighter construction than those fitted to the front. They can be hinged upwards to a vertical position as here, providing cover for passengers disembarking from the vehicle.

The Israelis have made great efforts to improve the vehicle's survivability. Emergency triggers for the fire suppression system are found beneath the faded red shrouds on the vehicle's glacis. The large antenna which towers above the vehicle's rear is used for electronic counter-measures. Its purpose is to block signals sent to detonate roadside charges. Smoke grenade launchers are fitted to both of the vehicle's flanks. Screening the front of the grenade launchers against dust is a tough textile known as Shimshonit.

In recent years most IDF vehicles have moved away from the Sinai grey overall colour scheme, towards one with a more marked olive drab tone. However, the Nakpadon, as this example, tends to be painted in Sinai grey. Whilst the paint applied to the vehicle's body has a smooth finish, the armour modules have a grainy texture. Israeli AFVs tend not to have gaudy tactical markings. As an exception to the rule, this carrier has sky blue identification bands, unique to Nakpadon units.

C1: MAGACH 7A ON PATROL NEAR THE PALESTINIAN CITY OF TUL KAREM, JULY 2002

This illustration shows the bulky, slab-sided turret profile of the Magach 7A. Tanks have proved useful during the second Palestinian *Intifada*, proving immune to RPG fire, at least over their frontal arc. The Magach 7A carries two large IMI grenade launchers, each holding ten projectiles.

An Achzarit on manoeuvres, Negev desert, 1997. The Rafael OWS mounts an FN 7.62mm machine gun. The crew are wearing flak jackets. Other than a registration plate, the vehicle is without tactical markings.

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Pumas photographed in upper Galilee, 1996. The insignia on the nearer vehicle's far left, shows that it belongs to the combat engineers. Note the heavy appliqué armour found on the front sections of the side skirts.

Tactical markings on the turret show that the tank is the second vehicle of the first platoon and the upwards-pointing chevron shows it belongs to the third company of its battalion. The single painted band on the cannon shows the Magach is part of the first battalion of the parent brigade. See the text for a full explanation of tactical markings and how to decipher them. The barrel ring and chevron have a shadow effect black outline to increase their visibility. The tank is painted olive drab.

C2: A MAGACH 7C ON MANOEUVRES, NEAR THE EGYPTIAN BORDER, AUTUMN 2000

Despite the peace treaty with Egypt, the IDF keeps much of its armour in close proximity to Sinai, partly because Israel's Negev desert offers space for training, and partly as a deterrent. The rather elderly Magach has been upgraded to a point where it can hold its own against more recent MBTs.

This view of the Magach 7C shows the heavy, arrowhead-shaped armour modules fitted to the turret. As well as a better ballistic profile, the modules give the tank a modern appearance which belies its age.

Although the tank is painted in olive drab, much of it is covered in a patina of yellowish desert dust. The tactical markings on this vehicle indicate that it is the Gimel or C tank of the first platoon, second company. The two white rings on the barrel indicate it belongs to the second battalion of its parent brigade.

D: THE ACHZARIT

The Achzarit illustrated was photographed on the Golan Heights in 1997. The machine is almost bare of tactical markings. Those present, the white number 2 and the upwards-pointing white chevron, indicate that the machine is from the second platoon of the third company.

In a prominent position at the front right-hand side of the vehicle is the gunner's crew station. It has a main unitary sight and x8 elbow sight, the former being on the left. The control box, ammunition selector and related items are mounted to the right and above the sights. Ammunition stowage is below the weapon station to the left and along the vehicle's right flank.

The commander's station is central at the vehicle's front. The commander does not have any vision blocks and has to raise his seat and fight the machine either with his head out of the hatch, or with the hatch in an 'umbrella position' giving reasonable protection and view.

The driver's station is relatively simple and crude. Available funding has gone into providing a decent transmission and power pack, not in providing a high-tech environment for the driver.

The passengers sit on a selection of simple, thinly padded benches and seats. There is a bench for three to the left. Just to the right rear of this bench is a single seat. Three additional folding seats are along the right side of the vehicle. Canvas or nylon grab handles hang from the roof to facilitate movement around the compartment.

Visible within the scruffy interior are the red-painted sensors and canisters associated with the vehicle's Spectronix fire detection and suppression system. The black corrugated tubing associated with the vehicle's NBC system is also prominent.

E1: MERKAVA 2 WITH FOURTH GENERATION ARMOUR ALONGSIDE THE LEBANESE BORDER, 23 JULY 2000

The hull of this Merkava 2B Dor Dalet demonstrates its distinctive add-on protection. The armour modules that have been attached to the turret sides stretch downwards, shielding the turret ring, a potential vulnerable point on the Merkava 2. In addition the side skirts extend upwards, their humped back shape intended to offer further protection to the turret ring.

The tank has been daubed with the usual olive drab. The main tactical marking that is visible is a single cannon barrel ring in white, indicating the tank belongs to its parent brigade's first battalion.

E2: MAGACH 6B BATASH IN ACTION ON THE WEST BANK, SUMMER 2002

The add-on armour on the Magach 6B BATASH's turret gives it a curved profile. The armour is a hybrid, made up of active and passive elements. It is optimised for use against HEAT warheads, ideal for counter-insurgency warfare. On the tank's glacis, the grid pattern of late generation Blazer tiles can just be seen.

The tactical markings, the Hebrew character Bet and the number 3, shows this tank is vehicle B of the third platoon of its unit. The tank is painted in standard olive drab, with the usual local dust coating some of the vehicle's surfaces.

F1: MERKAVA 3 BAZ DOR DALET AWAITING INSPECTION AT TEL HA SHOMER ORDNANCE BASE, DECEMBER 2002

The Merkava 3 Baz with its sophisticated fire control system is a formidable opponent. Here we have a pristine Merkava 3, upgraded with the Baz FCS and fourth generation appliqué armour to the turret flanks.

The fourth generation armour modules give the tank a similar appearance to the Merkava 2B Dor Dalet. However, the modules on this later variant do not extend down at such a sharp angle. In addition the 120mm cannon, as used by the Merkava 3, has a more bulbous bore evacuator. This provides a useful cue for quick identification.

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A Magach 7A photographed in December 2002 at Tel ha Shomer ordnance base. The slab-sided turret is clearly shown. The glacis is fitted with bolt-on passive armour. Note the hemispherical armoured shell which incorporates the commander's sights.

This Merkava 3 is painted in the standard olive drab. The tank's upper surfaces have a non-slip surface; fine grit is added to the paint giving the finish a grainy texture.

F2: MERKAVA 3 BAZ DOR DALET OF THE BARAK BRIGADE, AS PHOTOGRAPHED AT NAFACH JUNCTION ON THE GOLAN HEIGHTS, DECEMBER 2002

This Merkava was one of a group seen loading onto tank transporters at Nafach. Some of the fiercest fighting of the October 1973 war took place at this site.

The tactical markings are stencilled in white, with thin lines of black used to provide a shadow effect making the markings stand out at a distance. The Hebrew character Dalet and the numeral 1 indicate the vehicle is tank D of the first platoon and the chevron pointing upwards on the tank's side skirt shows that the tank belongs to the third company of its unit. Unusually the markings on the turret side have been painted on a rigid plastic screen, rather than the more common textile panels. The parent unit is thought to be the elite 188th Brigade, usually known as the Barak ('Lightning') Brigade.

G1: MERKAVA 4 AT SAYARIM BASE, NEGEV DESERT, WINTER 2002

The Merkava 4 has a very different turret shape than earlier variants; the profile has evolved as designers have sought to deal with the growing danger of top-attack missiles. The three armoured boxes on the turret roof are, from left to right, the commander's sight, the gunner's sight and part of the tank's defensive aid suite. Laser warning detectors are mounted on the turret flanks and front.

Typically the tank is missing some tactical markings but the downward-pointing chevron painted on the side skirt indicates that the tank belongs to the first company and the cannon barrel has a single white ring painted around it, indicating that the tank is from its parent brigade's first battalion. The white stripe painted along the top of the barrel is thought to act as a visual cue as to the position of the cannon barrel at night.

G2: MERKAVA 4 FROM THE FRONT, AUTUMN 2002

This frontal view of the Merkava 4 demonstrates that it has a much more symmetrical shape than the earlier models. There is no engine bulge to the left side of the glacis, the travel lock is mounted centrally, and the turret sides are similar in shape, angle and dimensions to each other. Note the new style smoke grenade launchers on the flanks of the turret and the abundance of sensors and optics on the roof. The turret is much wider than the wedge-shaped one pioneered by previous models of the tank.

Tactical markings on the left track guard show the Hebrew character Aleph followed by the number 1 and then a single horizontal white line, signifying that the tank is the first tank of first platoon, first company. The right track guard has a number 1 in a box. This indicates that the machine belongs to a brigade's first battalion.

The surface of the tank's armour is pockmarked by small rivets and bolts which act as a dust magnet. The machine has a greyish tinge to its olive drab, reminiscent of Sinai grey paint.

A Merkava 4 at speed. The turret has a different profile to earlier marks of the tank. Note the multitude of sights, and sensors on the turret sides and roof. (IDF Spokesperson's Office)

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